SCIENTIFIC AMERICAN

No. SUPPLEMENT, 320

Scientific American Supplement, Vol. XIII., No. 320. Scientific American, established 1845. NEW YORK, FEBRUARY 18, 1882. Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

RECENT ARCTIC EXPLORATIONS.

MUCH anxiety has been felt, both in England and in America, during the last two or three months of the past year, for the safety of the brave and patient men embarked in two different Arctic exploring expeditions, one directing its course from Europe, to the Polar sea north of Siberia round the Franz Josef Land archipelago, beyond Novaya Zemlya; the other, from America, proceeding in an opposite direction, to pass the large island called Wrangell Land, which is also situated north of Siberia, but lies off the north-eastern shore of the Asiatic Continent, and is approached through Behring Strait. The first-mentioned expedition was that of the Eira, fitted out and conducted by an English gentleman, Mr. Benjamin Leigh Smith. The second was that of the Jeannette, formerly called the Pandora, belonging to Mr. J. Gordon Bennett, proprietor of the New York *Herald*.

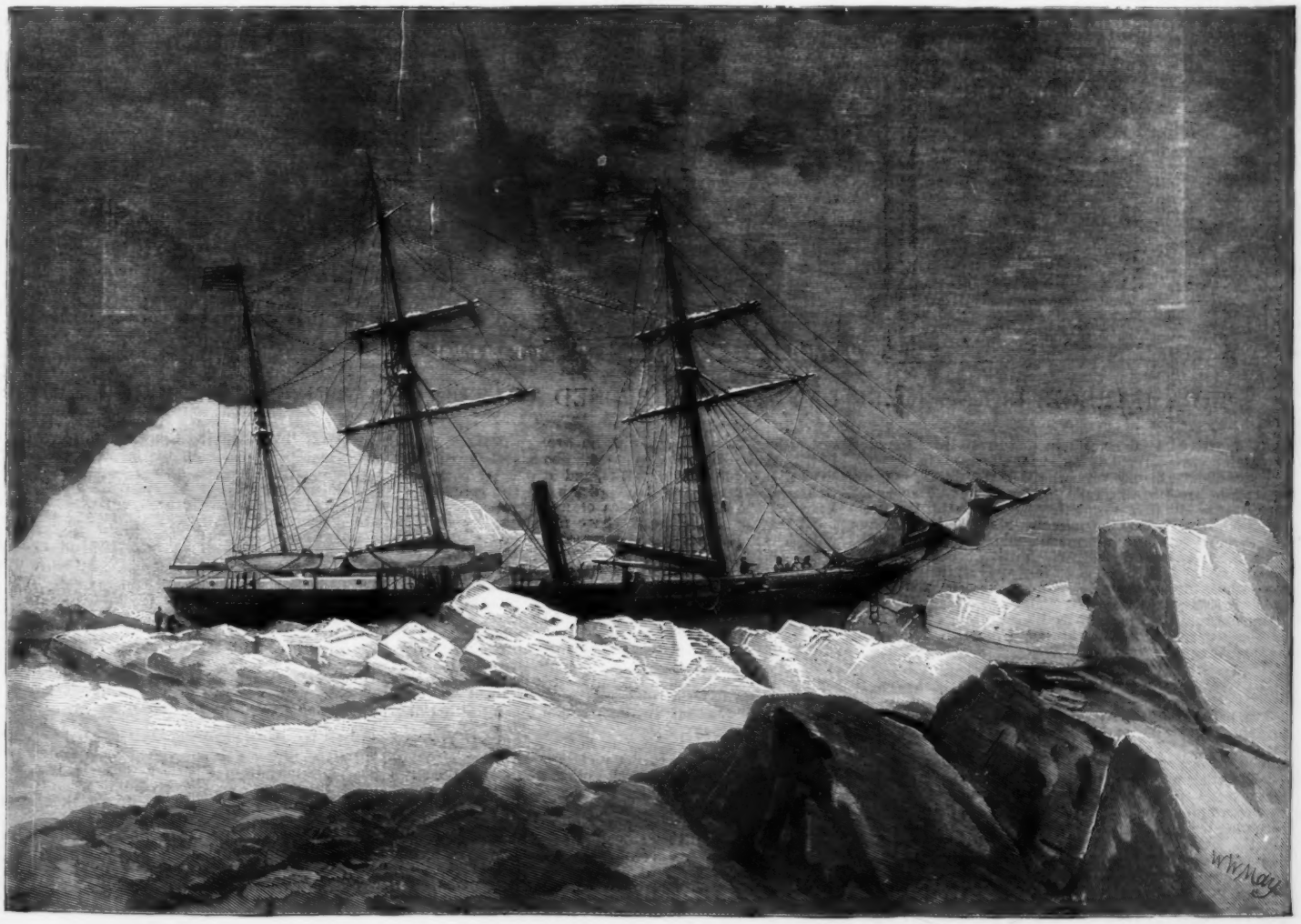
Mr. Leigh Smith has done good service to geography at his own sole expense, during a course of years having made important discoveries both in Spitzbergen and Franz Josef Land. He has expended at least £18,000 on this object, solely with a view to advancing geographical knowledge. The value of that service was recognized last May, when Mr. Leigh Smith received the high honor of being selected as one of the society's gold medalists for the year. The Eira, as is well known, was built by Mr. Leigh Smith, at Peterhead, in 1879–80, for the purpose of prosecuting summer voyages of discovery in the Arctic regions. She is 360 tons burden, builder's measurement, and fifty-horse power, 135 ft. long by 25 ft. beam. In the summer of 1880 Mr. Leigh Smith made a very successful voyage in her, during which he coasted the southern shore of Franz Josef Land and made some interesting discoveries. He sailed from Peterhead in the Eira, on her second voyage, on June 13 last. He had with him Captain Loftey, of Hull, as master, Dr. Neale, the surgeon, both of whom sailed in the Eira on her former voyage, and a crew of twenty-two men. He had provisions of all kinds for fourteen months, about two years' supply of bread and flour, and some additional preserved meats received from Gothenburg. His intention was to visit Franz Josef Land a second time, with a view to making further discoveries on its western side, and, if possible, to push northward near the meridian of Wicke's Land. But he would be guided by the state of the ice, using his best endeavors to enter upon new work in that direction which appeared most open and promising. The Eira was last seen by the Norwegian schooner Proven (Captain Isaksen) off the Matyushin Shar, on the west coast of Novaya Zemlya, on July 8 last. She was then going northward. Mr. Leigh Smith had no intention of passing a winter in the ice, and had consequently made no arrangements as regards a rendezvous in the event of accident, or for any other contingency. Indeed, it is certain that his intention was to return in the autumn. The continued absence of the Eira has given rise to very grave anxiety. She may either have succeeded in reaching the south coast of Franz Josef Land, and is now passing the winter in Eira Harbor or on some other part of that shore, or she has been caught in the ice to the north of Novaya Zemlya, and is in the drifting pack. As the Eira is not provisioned for a second winter, Mr. Leigh Smith cannot expose his men to the risk of being detained, and consequently he will be unable to wait on board his vessel until September, or even August, for the chance of being released by the breaking up of the ice. His supplies will only last him until August, 1882. It therefore seems likely that he will feel obliged to abandon the Eira in the early part of the ensuing navigable season, and endeavor to effect a retreat in boats by hauling them across floes and taking advantage of lanes of water, probably in the direction of Cape Nassau or Novaya Zemlya.

LIEUT. DE LONG, COMMANDER OF THE JEANNETTE.

We give an illustration of the Eira, and one of Eira Harbor, Franz Josef Land, where she may now be lying for the winter. They are from sketches drawn by Mr. W. J. A. Grant, during the voyage of 1880.

Mr. Gordon Bennett's vessel, the Jeannette, was formerly the Pandora, one of the steam gun-boats in the Royal Navy, which served a long commission on the West Coast of Africa. She was purchased by Sir Allan Young, who undertook a voyage in her to Barrow Strait and Peel Sound in 1875, and went a second time in her, in 1876, to be in readiness to assist the Arctic Expedition, in case succor should be needed. Sir Allan Young sold the Pandora to Mr. Gordon Bennett, who had resolved to dispatch an expedition, at his own expense, for discovery by way of Behring Strait. By an Act of Congress, it was arranged that the expedition should be officered and manned from the United States Navy, and should have the advantage of naval discipline.

Lieutenant De Long, to whom Mr. Gordon Bennett gave the command, is an accomplished young officer, who had already gained some experience in ice navigation when serving in a vessel which was sent in search of the Polaris up Baffin's Bay. He was ably supported by two other lieutenants, and a well selected scientific staff. When the Jeannette sailed from San Francisco in July, 1879, she had thirty-two souls on board, all told, and was provisioned for three years. Her orders were first to try and meet the Vega, the Swedish exploring vessel of Professor Nordenskjold, then supposed



THE JEANNETTE, MR. JAMES GORDON BENNETT'S VESSEL, IN THE PACK OF ICE.

to be working her way eastward along the Siberian coast, and to furnish any help that she might be in need of; then to push northward to the westward of Wrangell Land, which was supposed to extend far to the northward. These were wise instructions, for in advancing northward, in the polar regions, it is always desirable to make progress along a coast trending northward, with a western aspect. The Jeannette was seen by the whalers up Behring Straits, on September 3, in the same year, steering westward; and subsequently a report came from a Jahut that a steamer had been seen in the offing, on September 13, off the mouth of the Lena. From that time until September, 1881, nothing was heard of the Jeannette, a period of two complete years. The most intense anxiety naturally prevailed. We now learn, by Russian telegraph, that the Jeannette was crushed by the ice in 77 deg. 35 min. N. and 157 deg. E. This position is in about the latitude of Cape Chelyushin, the northern extreme of Siberia, but far to the eastward of it, and to the northeast of the Siberian Islands. After the loss of his vessel, it was necessary for Lieutenant De Long to retreat, with his brave comrades, to the Russian settlements in Siberia. He was 55° miles N.E. of the mouths of the Lena; and the direct line of retreat would take him through the narrow channels between the New Siberian Islands. The whole crew of the Jeannette, for there appear to have been no deaths, was divided into three parties, and embarked in two cutters and a whale-boat. They were separated by a gale of wind when only fifty miles from the Siberian coast. The third boat, in command of Mr. Melville, the engineer, reached the eastern mouth of the Lena, and put himself in communication with the Russian Commandant at a station to the southward called Bolonenga (or Bulun), who immediately sent forward provisions and assistance. The first boat, with Lieutenant De Long himself, and Dr. Ambler, the surgeon, arrived at the northern mouth of the Lena, and two of the crew arrived at Berlin for assistance in October. The second boat has not yet been heard of. It will not now be long before these intrepid explorers will be welcomed back to the civilized world; they have been for two years beyond the threshold of the unknown world, and they cannot fail to have collected information which will add to the stock of human knowledge. We heartily congratulate our cousins of the United States on the safety of their countrymen, whose fate was causing so much anxiety, and on the good work they must have accomplished.

Our portrait of Lieutenant De Long is from a photograph by Bradley and Rulofson, of San Francisco.—*Illustrated London News.*

THE TRIAL OF THE ALARM.

THE behavior of the Alarm, with its new steering apparatus, appears to indicate the success of the craft in everything except speed. The commander, Lieut. Commander R.M.G. Brown, reports to the Navy Department as follows:

"The trials have been entirely satisfactory in showing that a vessel of considerable size can be steered and propelled by a screw alone, without a rudder, so that the hull itself becoming the gun-carriage, a small vessel is capable of carrying the largest size gun, and of aiming it with certainty and precision. By means of this screw the vessel can be turned in place on its axis with a moderate steam pressure, making a complete circle in two and a half minutes, which is certainly less than half the time a duplicate vessel could complete the circle by means of a rudder and a speed of 12 knots an hour. And whereas the latter vessel would require a circle of 1,000 feet to turn in, the Alarm turns absolutely on her own axis without visibly moving from her position. As far as can be judged, the mechanical working of the screw was entirely successful, no trouble of any kind having been experienced with it. The vessel attained a speed of nearly 11½ knots, or 13⅓ miles, per hour. Had the motive machinery and the vessel's stern been constructed especially for this screw, the same weight of machinery would have given a speed of about 13 knots, or 15 miles, per hour. With machinery which could now be designed a vessel of the dimensions of the Alarm could be propelled at from 14 to 14½ knots per hour. For torpedo vessels and rams it is indispensable for maximum efficiency that they have the power of changing their course instantly, of turning and of backing; in brief, of maneuvering, with the rapidity and hardiness of a small boat with oars. The Mallory screws not only admit of this, but they are the only means thus far proposed that will effect these ends. I therefore am of the opinion that the development of the form of screw will be of great benefit in any system of naval coast defense. The Alarm now appears to be in good condition, and I trust and believe that she will prove an efficient vessel for war purposes. I consider her the most formidable vessel in our navy."

DEEP SEA SOUNDINGS.

AT a recent lecture in Providence, Rhode Island, reported by the *Providence Journal*, Commander Cheyne displayed maps of the different oceans outlined in his project of reaching the North Pole, showing where soundings had been taken and the varying depths of water. Our globe, it seems, contains about 197,000,000 square miles, 52,000,000 square miles being land, and about 145,000,000 square miles are water. The southern hemisphere has three times more water than the northern, with an average depth of 12,000 feet. About 80 miles from St. Thomas the soundings showed a depth of four miles, and at another place near Greenland the greatest known depth of water is five miles. Views of the different species of marine animals that inhabit the bottom of the sea have from time to time been published in the SCIENTIFIC AMERICAN.

Some of these creatures that are brought up from great depths by the trawl cannot stand the decreased pressure of the atmosphere below that of their native element, and upon reaching the surface their eyes are forced from their sockets and the fish soon die. The views must, therefore, be taken at once on being landed and while they still live.

Part of Commander Cheyne's plan for reaching the North Pole by balloon is to keep up communication with the earth by means of an insulated telegraph wire, 500 miles of which may be made to weigh no more than 200 pounds according to the showing of the Superintendent of the Western Union Telegraph Company.

Balloons have been sent up in the Arctic regions where the temperature at the earth's surface was five degrees below zero, F., and they acted as well as they would have done at a comfortably warm condition of the atmosphere.

It is proposed to send balloons off on the expedition in June, when the temperature is about the freezing point. It is expected they will float about 500 feet above the surface of the ice or ground, where, he thinks, it will be so warm that the excursionists will have to take off their coats. The sun's heat is expected to come through three different directions: First—reflected back from the snow and ice on the earth's surface; second—direct rays from the sun; and third—rays reflected from the balloon itself upon the inmates of the car.

The coal at St. Patrick's Bay, the proposed headquarters of the explorers, equals the best Welsh, and was almost smokeless. The gas to be used in the balloons will be a mixture of hydrogen and coal gases. The former would be too light and would permeate the balloons, while the latter is too heavy and does not possess the lifting qualities. But by mixing the two gases a more sticking and lasting gas is obtained.

The Hon. John R. Bartlett thinks favorably of Commander Cheyne's project, and has headed a Rhode Island State committee for taking into consideration the scheme.

GARRETT'S SUBMARINE TORPEDO BOAT.

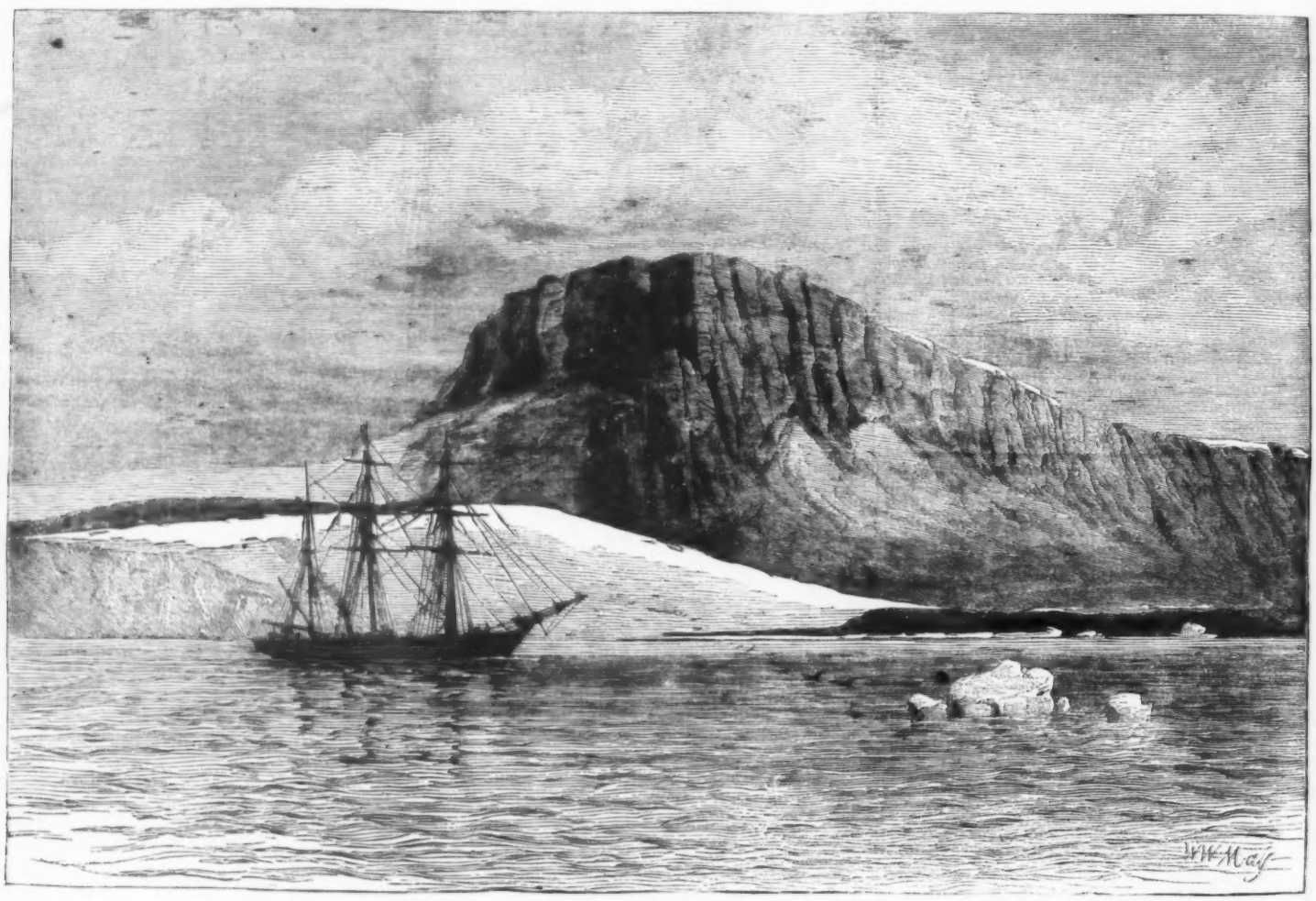
IN 1878 a good deal was heard about a submarine boat designed by Mr. Garrett, and with which several experiments were made. It was very small, and was propelled by manual power. All the trials made with it took place in one of the Liverpool docks, and Mr. Garrett remained under water for considerable periods.

In the autumn, 1879, he had a second and much larger boat constructed by Messrs. Cochran, of Birkenhead. The illustrations opposite show this second experimental boat, and are so complete as to need little explanation.

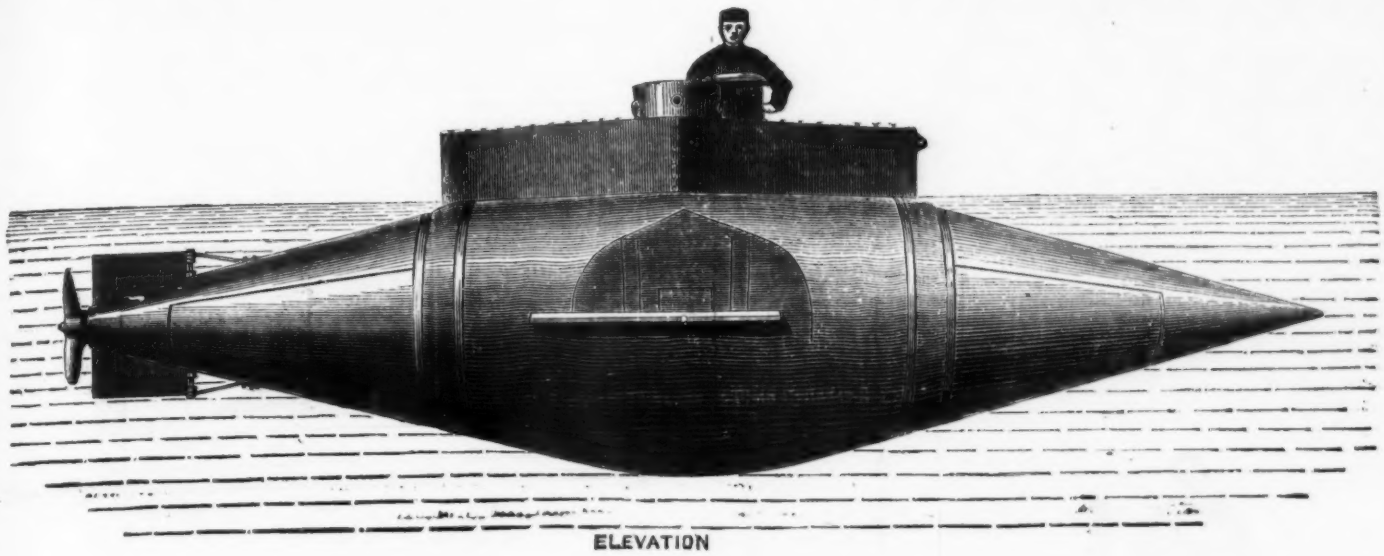
One of the leading features of the boat was the actual means of propulsion under water, which was attained by having a very large steam boiler, which carried a pressure of 150 lb. per square inch, and had great water capacity, which was utilized after the fire was closely shut up and combustion stopped. From experiments which were carefully made, there is no doubt that the vessel was capable of being propelled under water a distance of about twelve miles, simply by getting a full head of steam with the aid of the blower before diving below the surface, after which it was necessary to shut up the fire-door and chimney, and then go on utilizing the latent heat, evaporating the water contained in the boiler just on the same principle as that adopted in Lamm's fireless locomotive, until its exhaustion would compel a return to the surface to blow up the fire again and recharge the boiler with water. Owing to the untimely loss of the vessel off the Welsh coast, it is to be regretted that experiments in keeping up the furnace heat when the boat was submerged were not completed.

One of the leading features of this vessel was that when sailing below the surface there was no track whatever to trace her course through the water. The boat was managed by three men, and it was found that if one man in the conning tower had the secret breathing apparatus in use, the air of the boat was kept in a fit state for the other men to look after the management of the machinery. It will be observed the engine was of the return connecting-rod type, and was fitted with a surface condenser. The side rudders for submerging the vessel were worked from the conning tower, but their action was not fully experimented upon. The mechanical details of a perfect submarine boat would seem to be capable of a satisfactory solution, but the question of navigating such a vessel is still a matter of grave uncertainty.

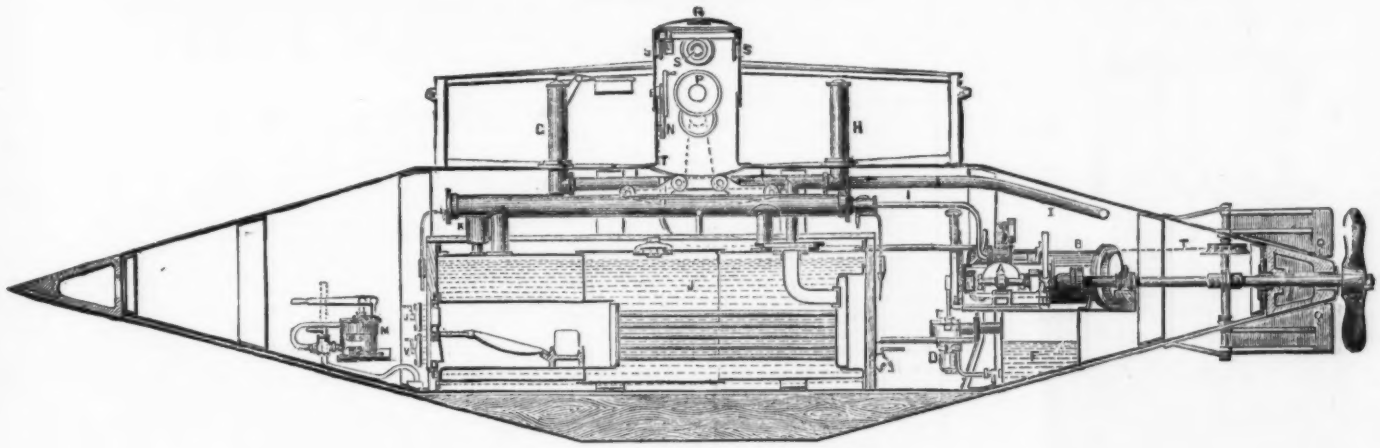
In the engraving, A is the cylinder, B condenser, C Roots' blower, D air and circulating pumps, E feed pumps, F hot well, G air pipe with automatic valve, H smoke escape valve, I air pipe to blower, J boiler, K safety valve, L blow off valve, M hand force-pump, N steering wheel, O side rudders, P side rudder adjusting wheel, Q rudder, R man hole, S bull's-eye lights, T steering chains, U air-tight furnace-door, and V the air-tight ashpit-door.—*The Engineer.*



EIRA HARBOR, FRANZ JOSEF LAND, THE SUPPOSED WINTER QUARTERS OF MR. LEIGH SMITH.

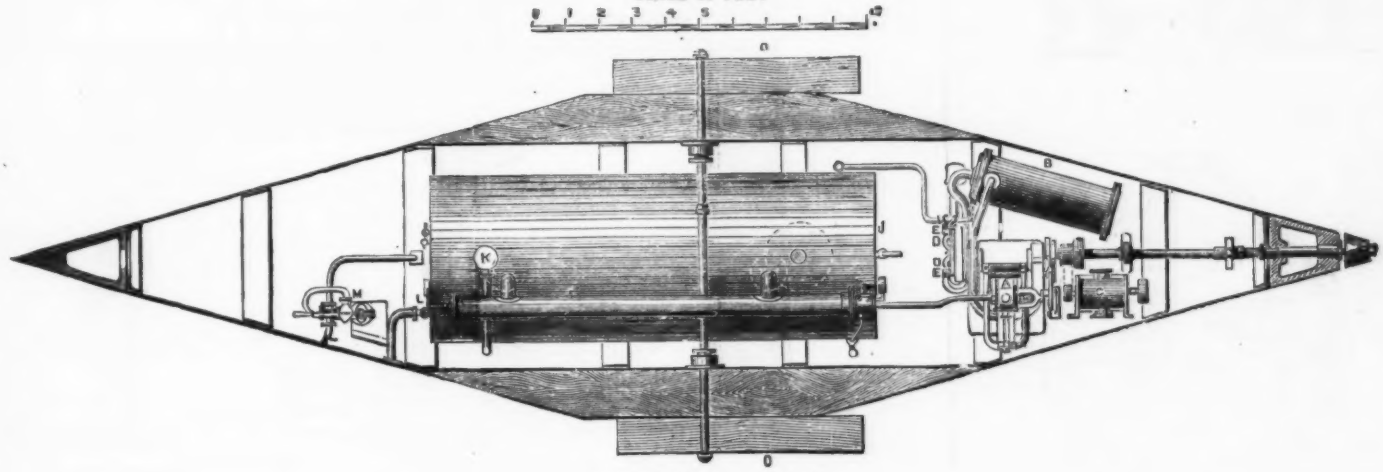


ELEVATION



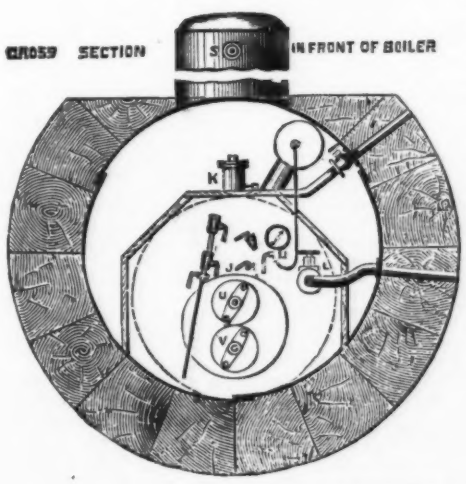
LONGITUDINAL SECTION

SCALE OF FEET

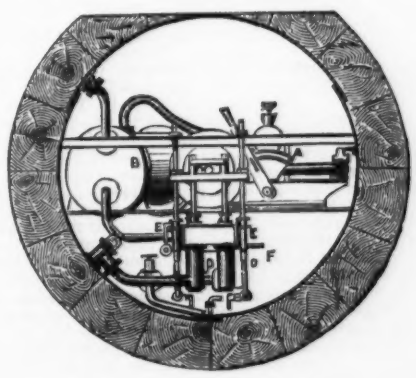


SECTIONAL PLAN

CROSS SECTION IN FRONT OF BOILER



CROSS SECTION THROUGH ENGINE ROOM



GARRETT'S SUBMARINE TORPEDO BOAT.

IMPROVED STEAM ENGINE.

We illustrate a steam-engine of novel construction, which has been invented and is being manufactured by Messrs. W. Von Pittler and Elze, of Leipsic. The chief points claimed for it by its inventors are, that it is of simple construction, and has a steam generator which is practically inexplodible. It is worked at high pressure, and, as it uses superheated steam, a great saving in fuel is effected. Fig. 1 of our engravings shows a sectional view of the engine; Fig. 2 being a sectional plan taken on the line, K L, of Fig. 1. The generator consists of a number of small wrought iron welded tubes, *i*, *i*, placed concentrically round the fire-box, A, and which are tested up to 450 lb. per square inch. B is the superheater, which is suspended over the fire-grate, and in which the working cylinder, E, is placed, so that the latter is surrounded by a highly superheated steam-jacket, which prevents any cooling of the working steam, and insures the application of the steam at a very high degree of expansion, consequently insuring a great saving in working. The piston works the crank shaft of the fly-wheel, direct power being transmitted by belting. The feed-pump, C, which injects the water into the lower part of the steam-generator, is also driven from this shaft. It has been proved that only about half the space in the tubes is filled with water, the remainder being occupied partly by a mixture of steam and water, and partly by pure steam, which obviates any danger

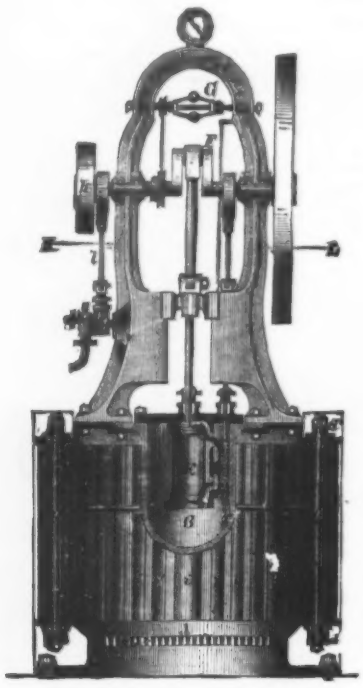


FIG. 1.

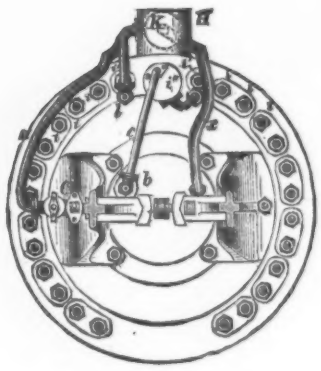


FIG. 2.

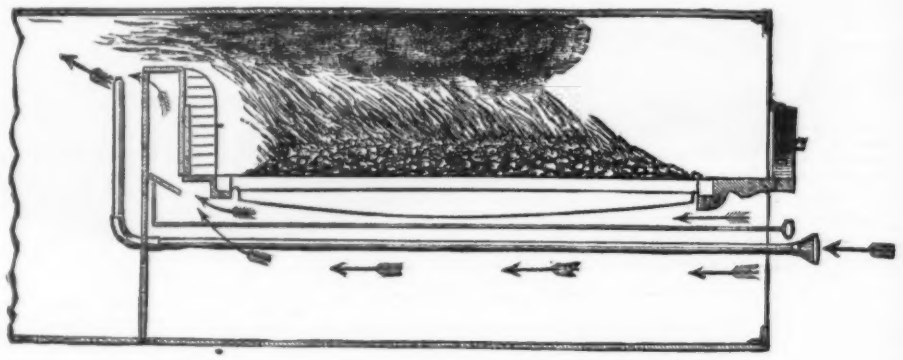
PITTLER AND ELZE'S STEAM ENGINE.

of explosion, notwithstanding the high working pressure of about 120 lb. per square inch, only pure steam being supplied to the cylinder.

Another peculiarity of this engine, of great practical utility, is its double regulating action, which applies both to the supply of steam to the working cylinder and the supply of water to the generator. By this double action the greatest regularity in working is insured. The manner in which this is effected is as follows: The feed-pump, C, forces the water through the delivery pipe, *a*, into the feed-water heater, K, when it passes through the pipe, *i'*, into the tubes, *i i i*, of the generator, and is converted into steam. The mixture of steam and water is admitted into the pipe, *i''*, which serves as a collector, and then enters as pure steam into the superheater, B, whence it is supplied direct into the cylinder, E, which is without a slide-box. In the delivery pipe, *a*, between the feed-pump, C, and the pipe, *i'*, a return valve is inserted, which prevents the steam entering the pump. A cock is placed in front of the return valve, by means of which the supply to the generator may be regulated. Between the superheater, B, and the collecting pipe, *i''*, there is a valve, *b*, connected with the regulator, by means of which the entry of water into the superheater is prevented. This invention appears to provide a safe and useful motor for small powers. It raises steam very quickly, and requires but little attention when working.—*Iron*.

A SMOKE CONSUMER.

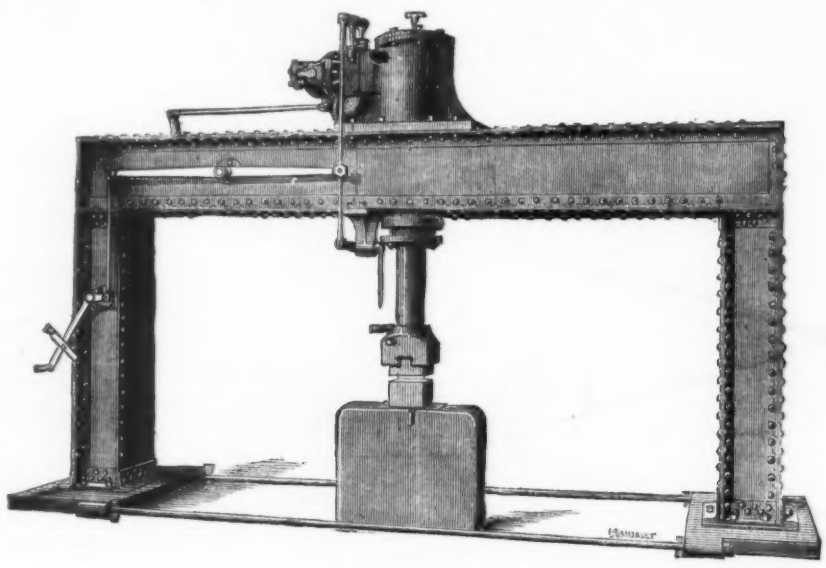
MR. E L. GOWTHORPE has invented a smoke-consumer for furnaces, which consists of a hollow bridge, with a door below to admit of a current of air passing through from the ash-pit, and which is given out warm through a slotted opening at the top of the bridge at the back. Heated oxygen is thus made to play upon the fluid carbon, escaping overhead. The under door of the bridge is opened by a lever. Two pipes, resembling speaking-tubes and fitted with similar stops, come to the front of the furnace, communicating at a little distance behind the bridge with a horizontal pipe, which rises to almost the same level as the bridge. This pipe is slotted at the back, and by the removal of the stops in front air warmed in the pipes is admitted to play upon such portions of the fluid carbon as have not been consumed by the hot blast from the bridge.



NEW SMOKE CONSUMING FURNACE.

STEAM HAMMER FOR BOSSING WHEELS.

THIS hammer has been made by Messrs. B. & S. Massey, of Openshaw, Manchester, specially for working upon locomotive wheels and other objects of large diameters but not requiring a very powerful blow. The framing consists entirely of wrought iron, there being no cast-iron flanges interposed, as is often the case in so-called wrought-iron framings. The plates are continuous from end to end without any transverse joints, and the edges are planed. The falling weight, independent of steam or momentum, is ten cwt.; the hammer head and face are of crucible steel; the longest stroke is twenty-seven inches, the diameter of cylinder thirteen inches, the clear width between pillars thirteen feet, the clear height beneath the horizontal girder six feet.—*Engineering*.



STEAM HAMMER FOR BOSSING RAILWAY WHEELS.

HOW RAILWAY TIME TABLES ARE ARRANGED.

THE process of making up the new winter time table of the New York Division of the Pennsylvania Railroad was witnessed the other day by a *Sun* reporter. Mr. Charles Watts, the train master of the division, arranged it before it was submitted to Superintendent McCrea. Mr. Watts laid out the trains by means of silken cords upon an immense board representing all the stations of the division and all the minutes in twenty-four hours. Along the top and bottom of the board are the figures for the hours and minutes, with ruled lines reaching from each figure on the top to the corresponding figure on the bottom. Down the sides of the board are the names of the stations, with similar lines connecting them. It is not known that there is any other board of the kind having lines for the minutes. There are many with five-minute lines, and some with lines for each two minutes. But so many trains are run on this division, especially for short distances out from Philadelphia and from New York, that a minute is an important factor in the time table. During a period of about an hour in each afternoon three fast lines leave Jersey City for Philadelphia, and before, between, and after them way trains are run to New Brunswick or nearer points.

The first thing Mr. Watts did was to put in the threads to represent these lightning expresses. These were all of one color. They were wound around a pin at the minute of departure, and carried down the board in a slanting direction to the pin at the moment of arrival in West Philadelphia. These fast line threads cover only a small area of the board, but a slow way train makes a very obtuse angle, and stretches far across the rows of minutes. The time of departure for these fast trains had not been altered, but he wanted to get a little more speed out of one or two of them if possible. In saving three minutes with one of them he experienced considerable difficulty. He ran his thread thirty miles over one section of the board before he could pick up a minute. He was taking into consideration his knowledge of things not shown on the board. For instance, he knew of certain heavy grades that defied better time than had been obtained during the summer. Then there was a draw bridge in another place, and a slow run through and just beyond Trenton, and at other points. There was one thing, however, that he could not take into account, important as it was. That was the possibility of high winds. He said that a stiff breeze opposing a fast line and striking the coaches at an angle rather than directly ahead will delay a train several minutes.

There was more difficulty about arranging the New Brunswick and other way trains. They must be kept so many minutes ahead of the fast lines. One of them started out several minutes ahead of one of the fast lines. He strung another colored thread from the pin at the mark of the minute of departure to the pin at the minute at arrival. The thread being obliged to cover a greater area of minutes than the fast line thread, drew near and dangerously nearer to its rapid neighbor. They looked as if they would run into one another on one block of the road. Mr. Watts hurried the train up by drawing it a little straighter, and thus removing the point at which the threads crossed, until he got down to the line marked South Elizabeth, where he knew there was an extra track for the New Brunswick train to make her way on, and there the pink line of the lightning express crossed the other line, and shot ahead without having been nearer than six minutes to the way train until they each took a track to themselves. Next the thread of a Trenton train was stretched, and it also was approached by a fast line thread only a short way out on the road. He arranged it so as to reach the neighborhood of Menlo Park at a safe distance ahead of the fast line, and then he tied the thread to a pin on one minute line and stretched it straight across to another pin a few minutes later in the day. Thus he indicated a siding on which the train rested until the fast line should rush past, and the way train could draw out and run behind the fast line.

"But where are your freights?" the visitor asked, adding, "I don't see a freight train on the board."

"No," said Mr. Watts, "we never schedule them. We run them all as wildcat trains. That is, they have no regular set time to run on, but do the best they can."

"They run mostly at night, I suppose?"

"No, they run at all hours, often getting a roadway for long runs and often being obliged to steal along between scheduled trains from siding to siding. The engineers have their time tables and understand their work so that they make the best of their opportunities; but I have known a freight train to lay by two hours within twenty or thirty miles of Jersey City waiting for a clear roadway."

MANUFACTURE OF GUN-COTTON AT THE STOWMARKET WORKS.

THE objects we have specially to consider now are—(1) gun-cotton proper; (2) gun-cotton sporting powder; and (3) the new form of dynamite. The processes of manufacture of gun-cotton were first seen, then a series of experiments were performed. The main principle to keep in view in manufacture is the completeness of the chemical action of the acid of the cotton in the formation of trinitro cellulose in the form of insoluble gun-cotton, and the removal of every less stable compound or impurity. This is effected mainly by mechanical means, that is, tearing the gun-cotton into minute threads and washing it in the form of pulp. Chemical means, that is the application of alkalies, have been tried, but it may be seen that, however completely free acid may be removed by alkalies, the less stable compounds will not be touched, and as these are found in interior parts of the cotton it is obvious that the only guarantee of security is the disintegration of the cotton and the washing out of these compounds in virtue of their solubility. Alkali may, with advantage, be added to gun-cotton for another purpose, namely, to enable it to bear exposure to a high temperature, that is, about 170 degrees Fahr., which is the highest to which it is safe to submit it in the judgment of Mr. Abel, whose experience on this question is so great that his opinion may well weigh down that of all private manufacturers combined.

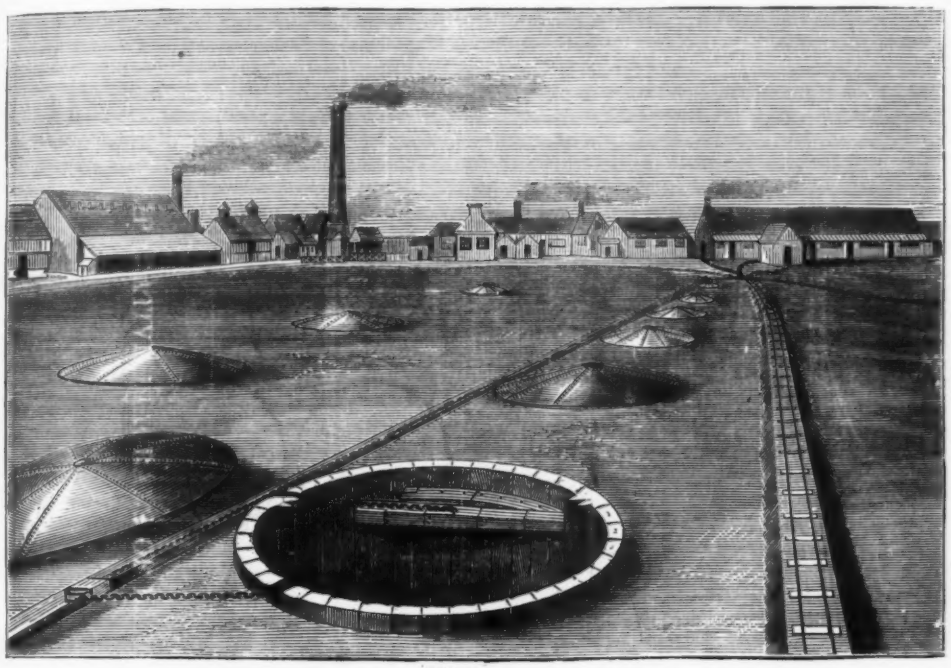
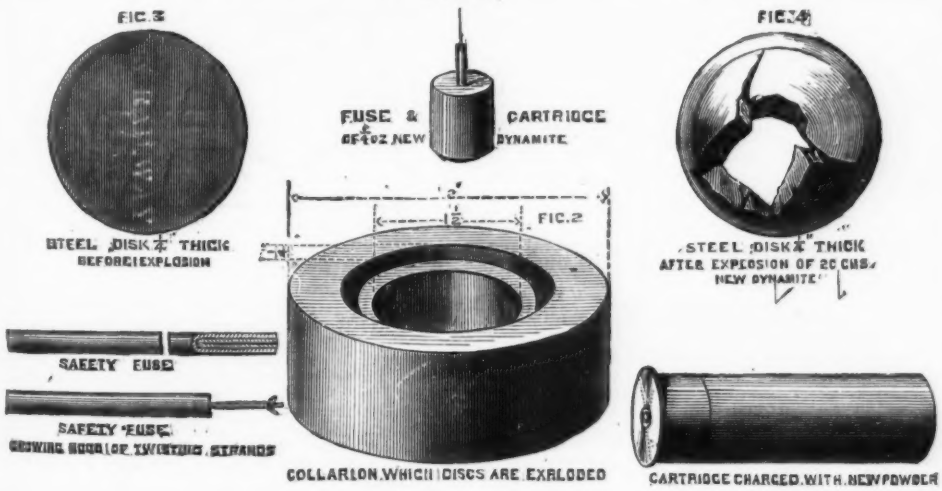


FIG. 6



THE STOWMARKET EXPLOSIVE WORKS.

The general arrangement of the works is shown in our engraving. They consist of little more than a series of sheds, in this respect resembling more or less all establishments where explosives are manufactured.

Picking.—The cotton employed is the best bleached white waste obtained from Manchester; it contains from 5 to 12 per cent. of dirt and impurity, which can be removed by picking. This is done by female labor: three girls can pick about 700 lb. per diem.

Teasing and Carding next follows. The cotton is now carded and wound on to rollers taking 28 lb. each.

Air Drying.—The cotton of three rolls is now dropped into a cylinder with a steam jacket; the hot air, at a temperature of about 160 degrees Fahr., is drawn through the cotton by exhaustion effected by a fan. After this the cotton is left further to dry in a zinc cylinder until it contains only about one half per cent. of moisture, when it is fit for the application of the acid.

Acid Mixing.—The sulphuric acid comes in carboys containing varying quantities of acid, generally about 160 lb.; the nitric acid in bottles containing 73 lb. Both are supplied from Messrs Prentice's works. A charger divided into two unequal parts then receives in one division 219 lb. of sulpauric, and in the other 73 lb. of nitric acid. On opening the bottom both are allowed to descend in a closed vessel, where they are mixed by the agitation of a T-piece, to which motion to and fro is imparted by a crank. The acid is run into tanks containing about two and a half tons each.

Application of Acid.—The cotton is immersed in the acid in quantities of 1 lb. weight. It remains in the acid for about two and a half minutes. For the sake of those who are wholly unfamiliar with gun-cotton, we may observe that the nitric acid alone acts on the cotton, the sulphuric acid being used only to take up the water which would otherwise be formed to the detriment of the nitric acid, which would check the action on the cotton and spoil it. It may be seen that the sulphuric acid is to the nitric in the proportion of three to one, and fresh acid is employed for every pound of cotton. The acid is pressed out of the cotton to a certain extent, and the latter left for about five minutes, when it is placed in an earthen jar containing only the pound of cotton with its acid.

Digesting.—Each jar of acid and cotton is now placed in in water to a depth of 6 inches to 8 inches, and left to cool for about twenty-four hours; each pound of cotton takes with it about 10½ lb. of acid.

Wringing.—Six charges of cotton and acid are now placed in a rotating wringer, which by centrifugal force wrings out about 9½ lb. of acid out of each 10½ lb.

Water Washing.—The cotton is now washed under a free stream of cold water, the cotton being stirred about on a perforated copper bottom by a pole by hand for about ten minutes or a quarter of an hour.

Centrifugal Water Washing.—Water is now run on the cotton while moving in a centrifugal machine or cylinder making about 1,700 revolutions per minute.

Boiling.—From 500 lb. to 600 lb. of cotton is now placed in a boiling vat on a wood grating. Boiling is effected by the passage of steam up through the water at a pressure of about 10 lb. The time which this process is continued varies from about four to twelve hours, depending on the chemical tests obtained in the case of each vat. The water should be neutral to test paper before the cotton is removed.

Beating.—About 500 lb. of cotton is now thrown into a tank with a wheel working in it against a raised portion of the bottom with steel strips; the wheel has also steel edges or blades, which shear the cotton against the strips and divide it finely. The revolution of the wheel causes all the water and cotton to pass round and round past it. Moving at a rate of 4,000 to 5,000 per minute, the wheel reduces the cotton to pulp in the water.

Poaching.—The pulp is now mixed in a "Poacher" or oblong wooden tub with wheel, with the addition of more water; the wheel in the poacher has three beaters, and revolves at the rate of eight revolutions per minute.

The Pulp Centrifugal House.—In a centrifugal machine the pulp now has the water carried out of it till it contains only about 25 to 30 per cent. It is now in the condition of pure gun-cotton.

Pressing.—Charges of about a half ounce of cotton are now weighed out by girls and passed on to a table, where boys press it in pipes with plungers into pellets sufficiently firm to enable them to be put horizontally into chambers in a metal plate, and pressed by hydraulic pressure—two and a half tons to the inch—until its specific gravity is about 1·5, in which state it contains about 12 per cent. of moisture.

Packing.—Brown paper prepared in resin, and rendered water-proof, is used for packing the gun-cotton pellets, previous to which, however, they are dipped and made to take up about 25 per cent. of moisture. If required, cotton pressed in this way can be cut by a revolving saw, which can be safely used when the cotton has 12½ per cent. of moisture—in fact, 40 tons were recently cut up in this way. The limiting quantity of moisture determining whether gun-cotton will burn or not is about 5 or 6 per cent. It is stored in boxes containing 50 lb. or 100 lb. in the moist condition—12 per cent. of moisture. If sent by rail, warning for a special van should be given, although, as a matter-of-fact, gun-cotton in this state does not readily ignite under ordinary conditions. Magazines are made in the form of circular pits dug 12 feet deep and lined with wood, as shown in the foreground of our engraving. It may be seen that this form of magazine is simple and suitable. The gun-cotton being damp the conditions of storage are quite different from ordinary dry powder, for which an unventilated hole in the ground would be very unsuitable. In speaking of damp gun-cotton as safe, it is of course contrary to reason to suppose that in a mass of fire it would not eventually become dry and ignite, or explode, according to circumstances.

The sporting or rifle powder is made of a combination of gun-cotton with nitrates of potash and soda, being, in fact, very nearly Mr. Abel's nitrated gun-cotton; it is incorporated in a mill under metal rollers, and granulated in a perforated zinc revolving cylinder, and eventually passed through a sieve suited to the size of grain desired. The grain appears to be hard and firm, comparing favorably with Shultz's powder; also, it is glazed so as to admit of being thoroughly wetted and dried again, which, of course, might be of great advantage if used on service. As we shall see presently, both bullets and shot are fired with this powder. At the same time we cannot advocate the use of gun-cotton cartridges with bullets generally, until exhaustive experiments have been made. In the Royal Arsenal, many years ago, it was found that very unexpected results were occasionally produced; indeed, rifles were burst without apparent cause. It may be said that cotton powder is now much better understood, but we think that to be satisfactory the cause of the occasional burst formerly obtained should be clearly discovered, and a very extensive series of firing trials should be successful. Possibly under certain conditions as to strength of cap and length of nipple, the gun-cotton may be fired in a manner approaching detonation. To guard against such a possibility a number of trials with more powerful caps and shorter nipples than those advocated might be made. The absence of smoke is an advantage justly claimed for gun-cotton. The decrease in noise is very well as far as it goes, but the absence of recoil is a much more questionable matter, implying that the work done on the piece is more local and sudden, and therefore more dangerous to the piece. In the Royal Arsenal, as the conditions became more satisfactory, a recoil was produced. In short, whatever may be done with shot cartridges, it would be well to proceed cautiously with bullets.

After firing a rifle with shot and bullets, with both powder and cotton cartridges, in order to exhibit the advantages claimed of absence of smoke and non-recoil, the following experiments were carried out: (1) Charges of five kinds of explosive compound of half an ounce each were exploded in lead cylinders four inches in diameter, one inch bore, length five inches.—(1) Gunpowder: This hardly acted on the lead. (2) Nobel's dynamite: This enlarged the cylinder and tore it open. (3) The company's new dynamite: This tore the cylinder open still more violently. (4) Mining gun-cotton, which is a form of nitrated cotton: This tore the lead rather less violently than the dynamite. (5) Pure gun-cotton, which tore the cylinder entirely across, dividing it into fragments.

The same compounds were now tried in order as to the effect produced on a steel disk a quarter of an inch thick—Fig. 3—placed in a collar of the form shown in Fig. 2, supporting it at its circumference. The powder produced no appreciable effect on its disk. Nobel's dynamite bent it into a shallow cup. The new dynamite effected a little more, perhaps; gun-cotton No. 2 gave nearly the same result, and pure gun-cotton produced a deeper cup, breaking the crown through, showing the impression of the shoulder round the edge as shown in Fig. 4, but no metal completely detached.

Rails—80 lb. steel—made by Messrs. Cammell, were broken by detonating seven ounces of dry cotton with one ounce of dry cotton used as a primer. A water tank over one inch thick was blown in pieces by gun-cotton. A charge of one and a half ounces was detonated with the help of one ounce of dry cotton. The shock in this case was transmitted through the incompressible water, as in the case of a water shell.

A tree was next cut in two by means of a ring of gun-cotton pellets placed round it. Lastly, a weight of 2 cwt. was dropped about 10 feet on to a box containing 5 lb. of pellets of dry gun-cotton without firing any of them. The cotton, which was crushed and broken by the fall, was proved to be dry by the ignition of some pellets by a match, when they readily burned. Eventually, before leaving the works, two submarine charges were fired in the canal.

We have said nothing of the new dynamite. It consists of nitroglycerine absorbed more completely and held more tenaciously than hitherto by a medium the ingredients of which are at present secret. Specimens of this substance and that of Nobel were shown in water. In the latter the nitroglycerine had oozed out. In the former there were no signs of it. If this quality can be obtained it is just the sort of explosive that is most valuable to engineers generally. The physical condition which enables a man to apply it to almost any mining job ought to recommend it strongly, while the prevention of escape of free nitroglycerine is most important as to safety. It may be added that this nitroglycerine is said not to freeze at so high a temperature as Nobel's.—*The Engineer.*

GUN-COTTON.

THE Explosives Company of Stowmarket invited a large body of visitors last Saturday to visit their works at Stowmarket, and afterwards to witness some experiments with gun-cotton, gun-cotton powder, and a substance called new dynamite. The process of manufacturing gun-cotton adopted at Stowmarket is that developed by Prof. Abel, of Woolwich. The raw material employed is the finest cotton waste, costing about £36 per ton, or double the price of the ordinary cotton waste employed so largely in factories for cleaning machinery. After having been carefully hand-picked, the waste is fed into vertical iron cylinders, where it is dried, by forcing in air having a temperature of 160 deg. Fahr., by means of one of Roots' blowers, the air being heated with the waste steam from one of the engines. When the drying process has been accomplished, the cotton is passed through a carding machine, is rolled up into cylinders, and packed away till wanted. The conversion is effected by immersing one-pound charges of the dried cotton in a mixture of the strongest nitric and sulphuric acids, in the proportion of three parts by weight of the latter to one of the former. The cotton only remains for a minute or two in the acid, and is then taken out, and as much as possible of the acid is squeezed out of it by means of a lever hand press. It is then put into wide-mouthed earthenware jars, covered with fresh acid, and the jars are allowed to stand in large shallow troughs of cold water to prevent undue heating for twenty-four hours. The conversion into gun-cotton is now complete. The remaining processes of manufacture have for their object the thorough cleansing of the cotton from the last traces of acid, and the packing of the cotton into the most convenient shapes for the purposes for which it is intended to be employed. The cleansing process is of the greatest importance, and is also most laborious. The gun-cotton when taken from the jars is thrown into centrifugal strainers, in which the greater part of the acid is expelled by means of centrifugal action. This is a most expensive process, as the cylindrical strainers are very costly, and are worn out by the straining of a couple of tons of cotton. After this the cotton is diffused quickly through a large volume of water, and again passed through the centrifugal strainers. It is next boiled by steam in large wooden tubs, then tested for acid, and if necessary reboiled. The next process is the pulping, which facilitates the cleansing from the last traces of acid, and also reduces the cotton to a condition in which it can be easily formed into cartridges.

The pulping machine is an oval wooden tub in which is set a horizontal revolving wheel of a diameter equal to half the smaller diameter of the oval. Strips of steel project from its circumference and under surface, and the cotton, which is swimming in water, is drawn in by the wheel, and passed out between its circumference and under surface and the sides of the tub, and is thus reduced by the steel strips to the state of pulp. The bottom of the tub is adjustable so that the space between it and the bottom of the wheel can be continually contracted as the pulping progresses. When the pulping is completed, the cotton is again finally washed by being mechanically stirred in water in large wooden tubs, and the pulp is then separated from the water by means of presses formed of large cylinders with perforated plungers worked by hydraulic power. The mass is then further pressed into its final shape, dependent on its ultimate use in a second hydraulic press, a pressure of six tons per square inch being applied. For small cartridges handworked lever presses are employed, the cartridge being then further compressed and finished in hydraulic presses.

The new gun cotton powder, or rifle gun-cotton as it is called, is not submitted to any pressure; the gun-cotton proper is first incorporated with another material, the nature of which is kept a secret, it is then roughly granulated in revolving drums, and afterwards finely granulated in machines which are not allowed to be seen. In appearance this new powder is of a bright yellow color, the grains are about the size of those of ordinary sporting powder, but extremely uniform both in shape and size. It is quite waterproof, and may be placed for months under water without injuring its qualities. A given weight of this material is equal in explosive force to nearly three times the quantity of gunpowder, while at the same time the recoil is very slight, and there is no smoke, and but little noise. The first experiments made last Saturday were with this powder. A very few shots were sufficient to convince the bystanders that it was a great improvement over the old fashioned powder. When fired from a Martini-Henry rifle, or 12-bore double-barreled fowling-piece, the recoil could not be felt, and the report was no louder than that caused by the explosion of a percussion cap. The penetration with 30 grains of the rifle gun-cotton was equal to that obtained with the usual charge of 3 drachms or 81 grains of violent sporting gunpowder. The absence of recoil can only be accounted for on the supposition that the charge burns slowly and progressively, thus maintaining a pretty uniform pressure throughout the whole length of the barrel. There was hardly any fouling of the barrel perceivable, and certainly no deposition of solid refuse. This latter is a most valuable quality, for deep-grooved rifles, like those of the Martini-Henry pattern, foul so rapidly with common gunpowder, that the recoil becomes excessively inconvenient. If rifle gun-cotton can be made as serviceable for artillery as it undoubtedly already is for small arms, it ought to have a great future before it, for one of the most serious causes of loss of efficiency of large guns is the great length of bore which is taken up by the cartridge, and which, of course, considerably diminishes the useful length of bore available for the purpose of enabling velocity to be imparted to the projectile. Now with the new powder a great saving will be effected in the bulk of the cartridges, and if the slow-burning and progressive action can be maintained in pieces of large caliber, great increase in initial velocity might reasonably be expected.

The next experiment was designed to prove that gun-cotton cannot be exploded by mere concussion, however violent. A box containing several cartridges of compressed cotton was slung over the front of an iron target, and fired into from a distance of fifty yards with a Martini-Henry rifle, and service charge. The box was perforated by the bullet, and the gun-cotton set on fire, but no explosion took place. A larger box was placed under a weight of two cwt., which was allowed to fall on it from a height of ten feet. The box and gun cotton contents were crushed to atoms, but no explosion occurred.

The next experiments were intended to show the use of this explosive for military purposes, especially for pioneers. A charge of five ounces of wet cotton and two ounces of dry was laid on a full-sized steel rail and exploded, the rail being shattered to pieces by the effect of the explosion, and an oval disk with a concentric oval ring of metal being blown clean out of the web of the rail, and buried in the ground. A similar experiment was made on some disks of steel two inches in diameter by one-quarter inch thick, supported round the edges. The charge in this case being twenty grammes, the disks were in some cases severely cupped, and in others perforated by the explosion.

A tree forty inches in circumference was cut down by the explosion of a ring of cartridges placed round the base. The cut was exceedingly clean, the wood not being shattered beyond the immediate neighborhood of the charge. In order to make this experiment succeed it is found necessary to fire the charge with two fuses fixed into two adjacent cartridges, with the object of making the explosion of the ring more nearly simultaneous.

The effect of different sorts of explosives was exhibited by firing quarter-ounce charges of gunpowder, ordinary gun cotton, torpedo cotton, and ordinary and new dynamite, in lead cylinders, four inches in diameter by about eight inches in length, the bore being one inch in diameter and five inches in depth. The relative effects produced were very interesting, and varied from the bulging of the cylinder by the gunpowder, to its being burst and rent into ribbons by the torpedo-cotton, which appeared to be the most violent explosive of the lot. The relative explosive forces of gunpowder and gun-cotton are given as one to six. The firing point of the cotton is about 360 deg. Fahr. The gases formed by its explosion are carbonic acid, carbonic oxide, water, nitrogen, and a little marsh gas, which clearly indicate that there is a deficiency of oxygen in the composition of gun-cotton. Sometimes a small quantity of nitrate of potash is added to the gun-cotton in order to make good the deficiency of oxygen.

The Explosives Company is about to manufacture the substance to which the name of new dynamite has been given on a large scale, at extensive works situated at Pembrey, in South Wales. Ordinary dynamite is, as is well known, a mixture of about seventy-five parts by weight of nitroglycerine with twenty-five parts of an absorbent earth called kieselguhr. This absorbent has the advantage that at some temperatures and hygrometric conditions, it allows the pure nitroglycerine to exude, thus greatly increasing the danger of handling the material, especially when it has to be thawed, as is always the case in cold weather. The new dynamite differs from this in the nature of the absorbent used. This is for the present kept a secret, but it is stated to be a substance which is itself an explosive, and which is capable of absorbing completely six times its weight of nitroglycerine, and which permits of no exudation.—*Engineering.*

AN IMPROVED DYNAMOMETER.

By WILLIAM P. TATHAM.

THE mechanical world has long desired a correct and convenient dynamometer, capable of general application. All of the instruments heretofore presented fail in some of the desired qualities. The Prony Brake, which is the most correct, absorbs the power, and does not transmit it. Dynamometers of the Morin type, which are next in accuracy, are of limited application to small powers, and of the many others it would be hard to find one in which the friction of the instrument is not largely represented in its indications.

To the old requirements for a good dynamometer we have now superadded the demand growing out of the generation of electricity from mechanical power and accuracy is here, as ever, the most to be desired. Under these circumstances, which sufficiently attest the difficulties of the case, I venture to describe an instrument involving the application of a new principle, in the hope that it may satisfy a pressing want.

Referring to Fig. 1, the arrows show the movement of the belts; the frame of the machine is omitted, the more clearly to exhibit the working parts. Let A represent the first motion pulley of the dynamometer, upon a shaft receiving power from any source outside; B B', two semicircular vibrating frames, having freedom to move around their central knife edges, C C', which play in valleys formed by the intersection of two small planes. These frames are linked together by two links at D and D', also on knife edges. The frame, B carries two pulleys, E and F. The pulley, E, is adjusted and centered upon the frame so that the central knife edge, C, coincides with the point of tangency of the belt, (*a*), with the pulley, E, the tangent point being taken at the middle of the thickness of the belt. By this

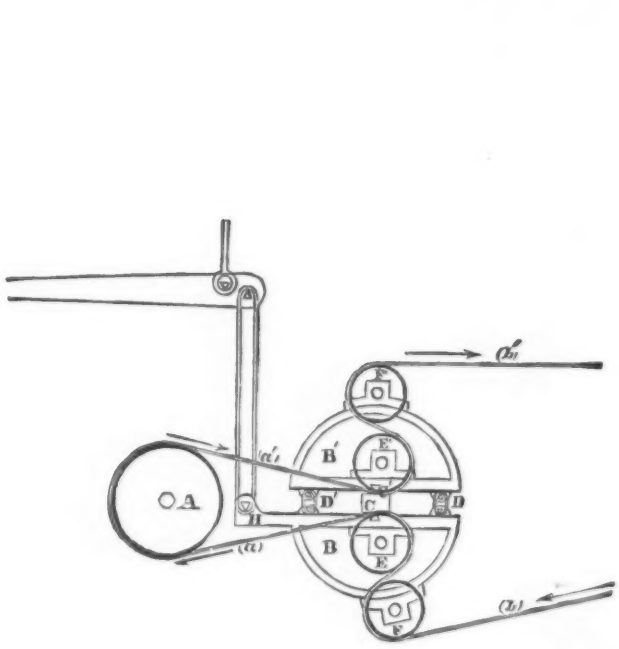


FIG. 1. TATHAM'S IMPROVED DYNAMOMETER.

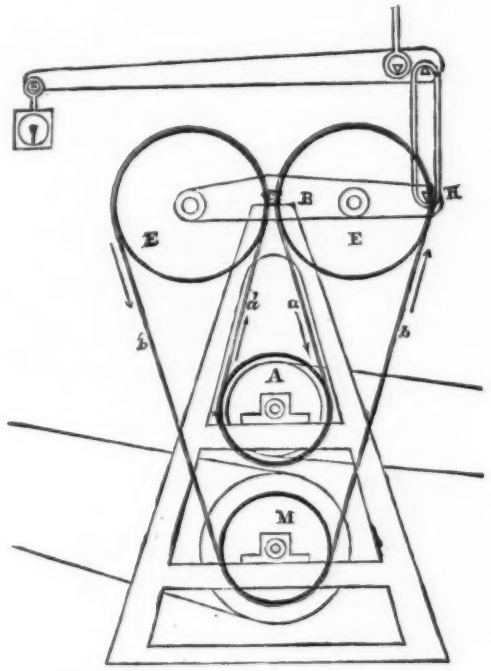


FIG. 2.

arrangement the force of the belt passes directly through the fulcrum of the frame, B, and therefore exerts no influence to vibrate it.

The pulley, F, is adjustable around the circumference of the frame, B, and is placed in such a position that the belt, (*b*), passing from the machine on trial, makes at its point of tangency with the pulley, F, a right angle with a straight line joining the tangent point to the central knife edge, C. The frame, B has an arm attached to it, to carry the knife edge, H, to which the link of the scale beam is attached. The distance of this knife edge, H, from knife edge, C, is equal to the distance of the latter from the point of tangency of pulley, F, and belt, (*b*) taken as before at the middle of the thickness of the belt.

The result of this disposition is that the only influence to cause a vibration of the frame, B, is the reaction of the belt, (*b*), which is exactly equal to the action of the same belt upon the machine on trial. In the same manner the action of the slack belt, (*b'*), upon the frame, B', is exactly equal to its reaction upon the machine on trial. The frames, B and B', being connected together by the links and knife edges, the difference of the tensions on (*b*) and (*b'*) is exerted to vibrate the two frames, and this difference alone is felt by the scale beam, all friction being eliminated except the friction of the knife edges. The rudely constructed working model which has been tried indicates the surprising accuracy when tested by a brake. To prove the elimination of the friction, the wheels, E and F, were chocked without change of indicated power.

I see no reason to doubt that this machine, when properly conducted and adjusted, would indicate correctly the power absorbed by the train of a watch, or given out by a water wheel; but it is still lacking in one very essential quality of a good machine—*it would not work well when out of order.*

When the journals of the wheels on the vibrating frames become worn by long use these wheels will be displaced, and their points of tangency with the belts will be displaced also, and the accuracy of the indications will be impaired.

In order to meet this requirement I have embodied my ideas in a different form, represented in Fig. 2. The arrows,

as before, show the direction of the belts. A is the first motion pulley and shaft; *a* and *a'* the tight and slack belts to the pulleys carried on the vibrating frame, B. These belts do not pass through the point of tangency, but *their direction does*. The vibrating frame, B, is balanced upon the knife edges, C, and is provided with knife edges, H, which engage the links of the scale beam.

The distance from C to H is equal to the effective diameter of the pulleys, E E', upon the vibrating frame; *b* and *b'* are the tight and slack belts from these pulleys to the pulley, M, which now takes the place of the machine represented in Fig. 1. It is important that the belts, *b b'*, should not make a less angle with the vertical line than the belts *a a'*.

The index will show the force exerted on the pulley, M, whose friction will be included. The friction of the pulley and shaft, M, can be estimated accurately by providing simple means for weighing the combined tensions of the belts, *b* and *b'*, upon the pulley, M, and then with the indications furnished by the dynamometer when running light and loaded, the friction when loaded can be calculated.

The speed of the belt may be measured by the counter, and the whole indication of power may be ascertained by combining a multiplied movement of the vibrating frame with a regular movement of a paper band fed from one of the shafts.

A critical examination of the last described machine will show that no probable wear and no probable change of the thickness of the belt can interfere materially with the accuracy of its indications.

The vibration of the frames need be very small. In the working model (if it were strong enough to bear it) 320 pounds would be indicated by the spring balance on the scale beam, and would correspond to a movement of 0·0375 inch of the knife edge, H.

In estimating the middle of the thickness of the belts as the points from which to measure the effective diameters of the pulleys governing the feed of belt and transmission of force, I have followed the books which have been confirmed by my preliminary experiments. In constructing an exact machine this point should be carefully examined.

A third form of the dynamometer, combining the accuracy of No. 1 with the wearing properties of No. 2, may be constructed by dividing the vibrating frame, B, of No. 2 into two frames, connected together by links each frame having its own fulcrum, C, in the line of the middle of the thickness of the belts, *a a'*, all the belts to be made vertical and pull at right angles to the levers.—*Jour. Franklin Institute.*

CARL LOUIS SCHWENDLER.

On the 6th January, 1882, at the village of Schoeneberg, near Berlin, after a long and painful illness, died, at the comparatively early age of forty-three, Carl Louis Schwendler, whose name will long be remembered in connection with Indian telegraphy. He was born on the 18th May, 1838, at Torgau, a fortified town in Prussia, where his father was a captain in a line infantry regiment.

When a schoolboy of 15 years, he depended entirely upon the support of a poor but devotedly-loved mother. That lady had not sufficient means to offer the talented boy the education which he desired, and thus necessity forced her to choose for him the humble and less expensive profession of a builder. He was soon apprenticed, and began his practical life as a bricklayer's laborer; but it was only natural that this occupation could not suit him long; his inclination for mathematical studies soon made him desert his first attempt, and he returned to a school preparatory for a technical academy. He nevertheless always kept an agreeable recollection of his first start and was ready to give a jocose description of olden times, when he mixed the mortar and carried it up the scaffolding.

Schwendler entered the Berlin Technical Academy as a student in 1856, and had then full opportunity to follow his inclinations, and combine his technical studies with those at the Berlin University, and thus he had some of the best professors as his teachers—Dove, Grasshoff, Rammelsberg, Weierstrass, Wiebe, Ritter, etc., etc. But the *nervus rerum* which unfortunately is so necessary for even the humblest life of a student, began to fail, and the limited support from home, combined with a small but hard-earned supply from private lessons, would not suffice. Schwendler had then but one hope in his despair. The corporation of his native town had stipends for poor students. He applied for support: but alas! he was refused. Those venerable gentlemen, taking into consideration that he had already changed his career, did not consider him a promising young man to merit their support. This was a hard blow to the student and an event which he could never forget, and upon which he delighted in after life in carrying out drastic joking whenever he visited his native town.

Schwendler was thus obliged to break off his studies before passing the Academy and to take a place in an office of a well known gas-engineer in Berlin. At this office, which was in the immediate vicinity of Messrs. Siemens & Halske's Telegraph Works, he happened to come in contact with Dr. Werner Siemens, who at once recognized Schwendler's talent.

Curiously enough he was at first put to the anvil, probably on account of his robust stature and physical strength. His superior mental powers, however, were soon detected, and he found himself in a short time in the laboratory of Dr. Werner Siemens, assisting Dr. Esselbach, Robert Sabine, and others in the redetermination of the Siemens mercury unit of electrical resistance, in which he was very instrumental. He also assisted in making determinations of the conducting power of other metals, besides investigations on the distribution of magnetism in iron bars, etc., etc.

We think about this time he had, in compliance with the military laws of Prussia, to serve his "year" as a soldier, and although the duties required of him left but little, if any, time for laboratory work, we believe we are correct in stating that he was allowed to draw his salary during the time as if he had been actually at work; an evidence at once of the kindly feeling and estimation inspired by the assistant and of the generosity of his employers.

He was in May, 1861, engaged upon experiments with the Malta-Alexandria Cable, and when the branch business of Siemens, Halske & Co., who had started as telegraph engineers some years previous in London, found it necessary to manufacture their own submarine and subterranean cables, it was Mr. C. L. Schwendler who was deputed in 1862 by the mother firm in Berlin to arrange the electrical part of the undertaking. He was chief electrician during the manufacture and laying of several cables for the French Government, and in 1863–64 was sent to the Mediterranean to lay one of these cables. A stay at Toulon was unfortunately unavoidable, as the cable had to be turned over, and this involved night work in an atmosphere strongly impregnated with the gases generated by the sewage of the good town of Toulon, in the form of floating, decomposing, and bubbling filth on the surface of the water in the harbor. Soon after leaving Toulon, Schwendler was, either at Carthagena or Oran, attacked by typhoid fever, and had to be left in the hospital in charge of a good sisterhood until his convalescence allowed of his removal, which, owing to his vigorous constitution, was not long delayed. After a somewhat adventurous voyage, during which the cable ship ran into and sank an orange boat in the Gulf of Lyons, Schwendler was landed at a town on the Gulf of Rosas, and traveled thence by easy stages home to Germany. On his recovery he returned to England, and took charge of the electrical department of Messrs. Siemens' cable works at Charlton, where in addition to routine work he directed his attention to several favorite subjects. In 1865 he, in conjunction with Mr. Sabine, contributed a short paper to the British Association meeting.

The following year, in the *Philosophical Magazine*, Schwendler published a valuable paper "On the Most Suitable Galvanometer Resistance to be Employed in Testing with the Wheatstone Bridge," which subject, till then greatly neglected, he had taken great pains to investigate both experimentally and mathematically. He retained his appointment with Messrs. Siemens Brothers until 1868, when Colonel Robinson, the Director General of Telegraphs in India at that time, found it was necessary for him to have an experienced electrician in order to put uniformity into the system of government telegraphs there. Through the good offices of his employers, Schwendler was recommended and accepted provisionally as Assistant Electrician to the Director General of Telegraphs in India early in 1868, and remained in that position as an employe of the firm of Siemens Brothers until the commencement of 1870. Highly appreciated for his integrity, ability, and amiability by the whole staff, he was offered by his chief a commanding position in the Government service as Chief Instructor of Indian Telegraphs, and acting under the instructions of the former he, soon after his arrival in India, commenced the preparation of his now well-known "Testing Instructions" for the guidance of the staff of the Government telegraph department there, the object in view being to facilitate the introduction and thorough understanding on the part of the officials of a rational system of testing the line and the technical arrangement of the offices.

The first part of these instructions was printed and issued to the department in 1869, in the form of a book containing about fifty pages, which was well received and met with deserved consideration both within and without the department, in spite of the fact that it was far from complete, in its author's opinion, having been prepared in a hurry under pressure of other work and during almost incessant traveling. The value of these "Instructions" was, however, subsequently evidenced by the fact that much of the contents was soon after quoted in professional text-books, and other telegraph administrations applied to the department for copies. These facts and the friendly encouragement received from the late Colonel Robinson induced Schwendler to elaborate his systems of testing still further, so that during the following seven years a series of such books was printed by the Government of India and issued. The spirit which animated Schwendler in this work may be best expressed in his own words in the preface to a reprint published in 1878. He says: "However much testing may become routine by continual practice, it *will* always, and *should* always, partake of something of the nature of a physical experiment, which must be conducted with a perfectly clear understanding. Then only can the tester draw the right conclusion from his observed facts, then only can testing become of real benefit to the administration."

In India, thanks to Schwendler's energy and clear headedness, combined with the hearty co-operation of the staff, these conditions have been fulfilled. Besides the performance of his official duties, Schwendler was busy with many collateral subjects of investigation, on some of which he contributed papers to the Asiatic Society, of which he was a member of council, and to the *Philosophical Magazine*. In 1870, he investigated and published "An Arrangement for the Discharge of Long Overland Telegraph Lines," and "A Practical Method of Locating Bad Insulators in Telegraph Lines." In 1872, he published a paper, "On the Best Resistance of the Coils of any Differential Galvanometer," and another paper, "On Differential Galvanometers;" in 1874 a paper "On the General Theory of Duplex Telegraphy," and one "On Earth Currents;" and in 1876 another paper "On Duplex Telegraphy."

In 1876, Schwendler received leave of absence and returned to Europe to recruit his health. While in England in 1877 he was elected a member of the Council of the Society of Telegraph Engineers and of Electricians, to which he gave his assistance until he returned to India. Early in 1877, Schwendler was requested by the board of directors of the East Indian Railway Company to institute detailed inquiries into the position of electric lighting in England with a view to the illumination of the Indian railway stations. Being, however, soon convinced that the subject was very little really understood by the majority of those in whose hands it had fallen, he proposed that before a practical trial was made at any of the Indian railway stations a series of experiments should be made upon which a correct judgment might be based. The board of directors having sanctioned the necessary outlay, experiments were commenced at the Indian office stores, Belvedere Road, Lambeth. The series which Schwendler there carried out was an elaborate, and as far as his materials went, an exhaustive one, occupying him until November, 1878. Having to return to India he was unable to finish a complete report before his departure, but he prepared a *précis* which was printed and issued.

In March, 1879, Schwendler read a paper before the Asiatic Society of Calcutta on the economy, practicability, and efficiency of the electric light for certain illuminating purposes, and on the best means of its distribution; the substance of the paper being of course based upon his experiments made in London. In the same year he published a paper on a new standard of light, and then reverting to telegraphy, we find a paper "On a Method of using a Small Fraction of the Main Current provided by a Dynamo-electric Machine for Telegraphic Purposes." This idea became a favorite one with Schwendler, and as late as last year he published a paper on "Some Experiments to supply all Lines terminating at the Calcutta station with Currents tapped from a Single Dynamo-electric Machine."

Of Schwendler's most recent life and work in India we know very little. Some years since, we believe, he suffered from an attack brought on by the heat of the climate, possibly what is known as a sunstroke, which his natural vigor and robustness enabled him subsequently to disregard, if not absolutely to forget, but which possibly laid the foundation for the fatal illness which necessitated his return to Europe, and to which he at length succumbed.

Those who enjoyed the pleasure of Schwendler's personal acquaintance will not need reminding of the brightness and almost juvenile buoyancy of his spirits which endeared him to all with whom he came into contact. He was impulsive and enthusiastic in private life as well as in his profession, but whatever he undertook to do, he did with his might, carefully and conscientiously. He was not ambitious to parade his name in "Brummagem" fashion before the world, and although better informed than the majority of the profession on the subjects he directed his attention to, he had no pedantic notions in his head, and never gave himself airs which could be offensive to anybody. In the very prime of his life and of a career of usefulness he was stricken down by a painful illness, out of which he has sunk to rest leaving many a friend and not an enemy.

He was essentially a self-made man, and by his energy commanded success, but success did not disturb or damage the purity of his mind and character. Open-hearted and natural he remained from his boyhood till his last days. He did not forget his poorer friends of days long gone by, and he would take the same pride in clasping hands as heartily with the workman of his earliest companionship as he would with men ranking highest in life. We have lost in Carl Louis Schwendler not only a man of science, whom we can ill spare, and who ranked with the highest in the telegraphic profession, but a man of purest character and humanity. He was interred on Monday, the 9th of January, in the quite village churchyard of Schoeneberg, near Berlin, followed by a multitude of college friends of his youth and professional admirers, bewailed by his aged mother, whose mainstay he had been through life.—*Electrical Review.*

HINTS ON HOME SANITATION.*

By H. H. COLLINS, F.R.I.B.A., F.I.S., Hon. Sec. of the Health Department, Social Science Association.

ALTHOUGH we cannot always select, yet we can all discriminate, with regard to the amenities and surroundings of the locality of the house we intend occupying. Given a certain number of residences from which to determine, we may choose that one which, from various reasons, is the one most free from objections, and which possesses the fewest defects. For example, we may endeavor to avoid a too-crowded locality—one surrounded by narrow and ill-ventilated streets, alleys, or lanes, the devitalized air of which would be sure, sooner or later, to prejudice the one we are about taking. We may give the preference to a detached or semi-detached house well bathed in air, to that of a terraced house, cribbed, cabined, and confined. We may choose between two sides of a street, so as to obtain the best aspect, say a south or southwesterly one in lieu of the other points of the compass. We may select a gravel, loamy, or well-drained subsoil in lieu of a damp, ill-drained clay one; and we may carefully refrain from dwelling in a house the foundations of which rest on fœtid *débris* or former dust receptacles. We can easily ascertain if illness has been prevalent in the locality. We can see if roads are made, and with what materials, and we can easily ascertain if the same have been "taken to" by the parish, sewered, lighted, and supervised by competent responsible authority.

Before entering into the occupation of any house we may protect ourselves against the incalculable evils arising from bad drainage, or roofs not watertight, by obtaining a verbal or written assurance that the same are perfect and the house consequently fit for habitation. It would be advisable to secure such a guarantee in writing, or such assurance given in the presence of witnesses. Quoting from the judgment of Mr. Baron Pollock, it will be seen that if such assurance is given, ignorance, or carelessness upon the part of the landlord will not excuse him: "If persons take upon themselves to make assertions as to which they are ignorant, whether true or untrue, they must, in a civil point of view, be held as responsible as if they had asserted that which they knew to be untrue." Mr. Justice Kay, in another judgment, said, "Now, what is enough in law to make a man liable for an action for deceit? It is enough that either he knew the statement he made was not accurate, or he made it recklessly without having knowledge about it one way or the other." Lastly, with respect to exterior considerations, we should give the preference to that house which has the thickest walls, the greatest amount of light, and appears to be the most substantially constructed, carefully avoiding being led away by a showy exterior, however picturesque, or overload with (too often) meretricious ornament, for most of these so-called advantages are the means of retaining dampness, garnering filth and dirt, and preventing the escape and evaporation of the natural humidity of our climate.

The dust-bin should not escape our notice; we should take care that it is so positioned are not to prove a nuisance; properly ventilated and moved as much away as possible from any of the ingresses to the house; nothing but dust and ashes should be allowed to be placed in it—vegetable and matter liable to decay should be burnt each day. The first consideration with regard to the interior of the house is its sanitary condition.

Assuming that its external drainage is guaranteed and perfect, we must carefully see that there does not exist any connection with the main sewerage and the house proper. This is not difficult. See that the waste pipes from the sinks are open at their ends and pass outside; also that the overflow-pipes from cisterns are similarly treated. A simple plan for keeping waste and overflow pipes clean is to obtain a cane and bind round its end a piece of rag or sponge, wet the same, and pass it up the pipe once or twice. See that sinks are placed against external walls and under window openings.

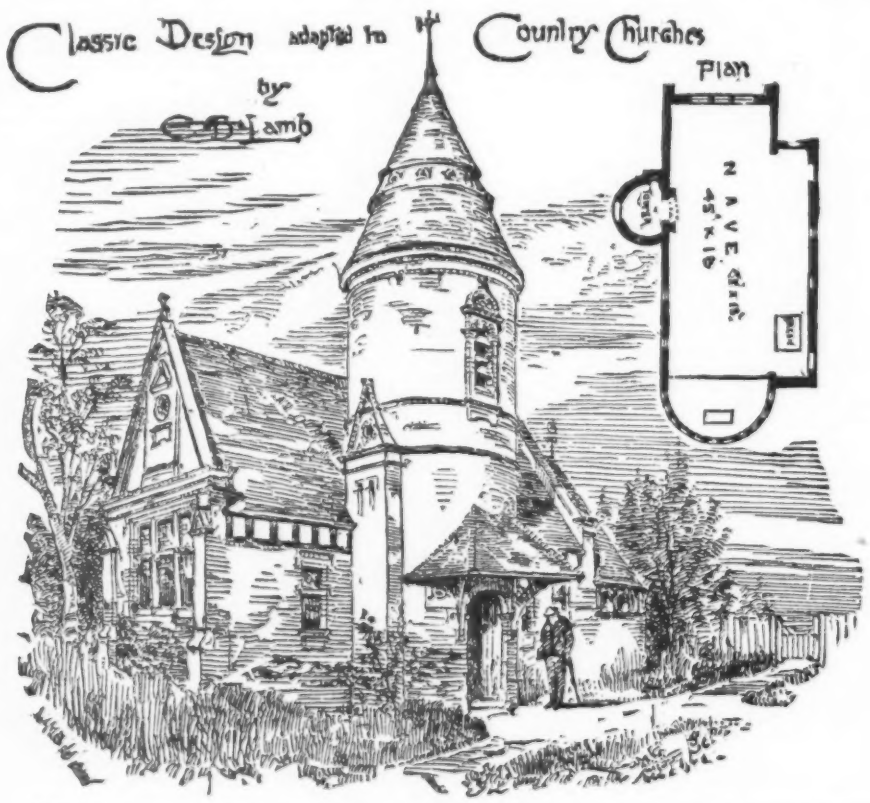
Ascertain the position of w.c.; if situated in the center of the house, give the preference to that house where the conveniences are positioned against an external wall, and lighted and ventilated from the outside; recollect that w.c. off staircase landings are the best. Take care that the w.c. are supplied from a separate cistern, so that no communication exists between the drinking-water cistern and themselves; this can easily and economically be effected by interposing a small waste-preventing cistern if it be necessary. See that the soil-pipes are of lead, and carried up their full bore above the roof, away from all windows or other ingresses to the house. It is an ordinary practice to make common light cast-iron rain-water pipes serve both for soil and rain-water; this should not be permitted, but if the landlord objects to substitute lead for iron, then take care that the joints of the iron pipe are thoroughly air and water tight, and that the pipe is carried up above the gutter as just mentioned, and a branch put in to take the rain-water. In any such arrangement it is essential that the soil

* Paper read at the Brighton Health Congress, December, 1881.

pipe be exterior to the house. If possible it is very desirable that an open trap, Potts' Edinburgh or Buchan's, should be inserted at the feet of these soil-pipes. Pan-closets should be avoided; simple earthenware hopper closets are much preferable and more economical in first cost. If safes or trays are placed under w.c., take care that the overflows therefrom pass direct into the open air. Let me recommend you to always close down the flap of the w.c. every night, shut the door, and slightly open the window, and once or twice a week to have the basins washed out with dilute spirits of salt. There exists no reason why the basins of the w.c. should not be as clean and the water as pellucid as that of a drinking-fountain.

Ascertain the position of the cisterns; these should be accessible, so that they may be cleansed out frequently, as, if placed in roofs, under stairs, or jammed into sculleries, they soon become neglected and sources of disease; all cisterns should be covered. All drinking-water should be boiled and filtered, and if charcoal be employed as the filtering medium the same should be renewed at frequent intervals. Several filters worthy of attention are to be found in the exhibition, notably the Carferal and Maignen's "Filtre Rapide." If the bath forms, as it should do, a portion of the fixtures, take care that its overflow and waste-pipe discharge into the open air, and I should advise that means be taken to carefully shut off draughts by placing India-rubber seatings between the wood and metal work (the same observations apply to w.c.). Similar remarks apply to all fixed lavatories, slop-sinks, etc., which should always be placed next external walls, and not in the center of houses, where they are most productive of prejudicial effects.

Let your preference be for that house which has an amplitude of light, is free from dark and unventilated passages; cupboards, closed dressers, nooks, and corners are not always the conveniences they appear to be; they form, as a rule, receptacles for all the neglected dirt of a house to congregate in, and are fruitful sources of danger; every house wife will recognize that by exposing to the full light of day



SUGGESTION IN ARCHITECTURE.—From the *British Architect.*

the pots, pans, and household requisites, she will be better able to preserve them clean, and what is equally necessary, whole, unbroken, and fit for use. Never use as a bed-chamber an apartment without a fireplace, for here it is that "the death of each day's life" occurs when vitality requires all the assistance which can be afforded to it.

Ventilation is of vital importance to the hygiene of house and occupant. Guard yourself against the inconvenience and annoyance of smoky chimneys by special agreement with your landlord, but a smoky chimney is even better than having none at all. A simple and cheap means of obtaining ventilation without draughts is the insertion of a board about three inches wide between the bottom rail of the sash and the sill of the window; but if you can obtain from your landlord fireplaces having hollow chambers formed round same, so that in winter air may be admitted in a warmed condition, and in summer in a cooled state, so much the better; many such are to be seen in your exhibition.

I have hitherto spoken of the admission of pure air, but it is equally, if not more, necessary to extract, or at least to allow egress of, the foul air. This can be readily obtained by means of Sheringham's ventilators, Arnott's valves, and contrivances of a like nature being inserted in the outer walls, or in special flues, or in the chimney breasts, and at very little cost. It is very desirable that all halls and staircases during the winter should be warmed; a good gas-stove will, if there be no other way, be a simple means of procuring this; but never adopt gas as a heating medium without the stove or apparatus is furnished with a flue to permit of the escape of the impure air; nothing can be more dangerous to health than the neglect of this hint. Attention should also be given to the state of the gas service; it should be examined and tested with a taper to see if there be any escape.

As regards the appropriation of rooms, of course this depends on the class of house; but as a matter of common sense, and consequently of sanitation, there is no difficulty in any class of house to select proper aspects for each apartment, bearing in mind the purpose for which they are to be devoted; thus: the dining-room, as probably the least used room in the house, many have a northerly aspect; the sitting and drawing-rooms, southerly and westerly; the kitchens, westerly; the larders, etc., northerly; nurseries, the same as sitting rooms, and so forth; so that the largest amount of health and enjoyment may be extracted from even an ill-planned and ill-arranged dwelling. A "hint" as to paper-hangings will not be amiss; take care that they are not arsenical in color and composition. One "hint" more with regard to the house and its belongings, worth all the rest; do not imagine that when structure, drainage, water supply, and the various appliances appertaining thereto, are left in perfect condition, that they will always remain so, and that, unlike every other production, they will last unimpaired for ever, or even that period of "for ever," a few years.

If you desire health, you must work for and deserve it; constant supervision to insure great and continual cleanliness is essential. You cannot "nag" your domestics too much on this score; you cannot be too watchful, whether the house be large or small, whether it belongs to peer or peasant, if you wish to preserve it as a pure wholesome dwelling in which to live, instead of to die in. This is a duty you owe to society quite as much as to yourself, bearing in mind that public sanitation is mainly, if not entirely, dependent upon private hygiene, and that the law declares in unfaltering accents, "Sic utere tuo ut alienum non lædas." ("That people must make use of their own property in such a manner as not to injure that of others.")

But there are other hints equally necessary to glance at—such, for example, as food. I am afraid, as a rule, it is exceptional for the lady of the household to pay that attention to the kitchen department as was the honored custom of the last century. In aristocratic families the duty devolves on the housekeeper, who relegates it to her assistant, who hands it on to some underling. In middle-class life, the cook, whether she be skilled or unskilled, reigns supreme. In the less elevated classes, an utter ignorance seems to prevail of dietary necessities. Goldsmith tells us that "Heaven sends us good meat, but the devil sends cooks;" and if this latter gentleman have an existence, I am sure a large proportion of my audience will be of the same opinion. How can "good digestion wait on appetite, and health on both," when the elements of the chemistry of food and cooking are absolutely unknown to the housewife? The hint here is to practically make yourselves acquainted with "what to eat, drink, and avoid." How much thrift may be engendered; how much household saving effected; how much good-humor secured; and how much health preserved by a little knowledge and some care given to this subject! First, as in all chemical operations, absolute cleanliness is required in pots, kettles, and utensils. Due weight—this will not suit the butcher. Purity of concomitants—a wail from the grocer! Economy in their use—warning from the cook! The meat weighed and washed; the vegetables cleansed, salted, and soaked; the fish carefully examined and well cleansed; the cloths free from impurities; the knives, spoons, etc., etc., clean and fit for use. Lastly, the result, a delicious meal, effected at half cost, productive of comfort and replete with health-giving properties.

Sanitation is so wide a subject, and embraces so much that is essential for the welfare and comfort of mankind, that "hints" might be multiplied *ad infinitum;* but I cannot conclude without calling your attention to one other matter of every day but yet of equal importance with the other subjects to which I have directed your attention, namely, "clothing." Dr. Max von Pettenkofer, Professor of Hygiene at the University of Munich, writes: "One of man's principal defensive weapons in his struggle for existence is his clothing; the place it takes in the history of civilization and its connection with physiology are not often thought of; it is spoken of from a moral and æsthetic point of view; its main purpose is a purely hygienic one." He adds that "the forgetfulness of this is to be deemed a great misfortune, inasmuch as small and frivolous considerations have subjected mankind to many ills, and have often acquired an ascendency over better and fitter hygienic clothing." The seeds of grave disorders and chronic illness are frequently—very frequently—promulgated by the neglect of well known principles with regard to clothing. This is a large subject, and I would refer you to Pettenkofer's work, wherein you will find much instructive and interesting matter; but I would mention that he calls attention to the fact that we generally consider clothing as an apparatus for keeping air from us, while in truth we could not bear any garments which did not allow of a continual ventilation of our surface. It is therefore necessary that we should make ourselves acquainted with those textures which, being most permeable, afford us the warmest clothing.

It is not the densest, thickest, or heaviest material which is best suited for our purpose. My "hint" on this head is that, as our health is so intimately associated with the economy of our dress, you should begin to think for yourselves with regard to it; emancipate yourselves from the tyrannical dominion of fashion, and study to obtain a deeper insight into those laws of clothing which will inevitably tend to increase the longevity of the community and to enhance its comfort and enjoyment. There are, as I have said, a host of other subjects connected with domestic sanitation, such as those relating to furniture, etc. On this head I would "hint" at the desirability of taking care that it should be of such form and character as to prevent the lodgment of dirt and dust; all hollows should be filled in, and all unnecessary ornamental projections dispensed with; under any and all circumstances a continual application of elbow-grease is very advisable. Too much caution cannot be exercised with regard to various matters external to the house, but often productive of serious consequences internally, such as the selection of the laundress, charwoman, seamstress, tailor, etc. It is a "hint" worth attention if the lady of the house would visit, or at least ascertain the character and surroundings of the homes and workshops belonging to these people before availing herself of their services; good in countless ways would result from such knowledge.

As my pen writes these concluding observations, I seem to hear a murmur that I have quite lost sight of the remark with which I commenced this paper, and the question inevitably arises, "That since life can little more supply than just to look around us and to die," is it worth the trouble of practically adopting the many hints laid down for our guidance? Cui bono? Has ever a people so lived, and if so, with what results? My answer is, Yes, and with the happiest and best of results; results which were intended for all, and which all may attain.

Without entering into any polemical disquisition as to whether the laws to which I am about to refer were of Divine origin or not, or whether they have been acted upon by religious or superstitious motives; that they were wise and beneficent, if we judge only by results, there can exist no doubt. The laws embraced every matter upon which I have lightly dwelt—household, dietary, personal, sumptuary, and every conceivable sanitary question affecting the happiness and life of mankind. Explained and amplified by the savants of the Jewish race, they have acted as their guiding star for over 5,000 years, and have preserved them in health under unexampled difficulties up to the present day. Dr. Richardson thus writes: "Facts show that from some cause or causes this race presents an endurance against disease that does not belong to other portions of the civilized communities. The resistance to those influences which tend to shorten the natural cycle of life is singularly instructive." He gives statistics which show that among infants 10 per cent. die among Jews, and among other denominations 14 per cent. That the average duration of the life of the Jew is 48, of others only 36. That a quarter of the Jews live beyond 71 years, and of others 59 years and 10 months. That the extracts from the civil state papers of Prussia show a mortality of the Jew 1·61 per cent., as against the mortality of the whole kingdom of 2·62. That the annual increase of the Jews is as 1·73 to 1·36 among other denominations. He adds the Jews escape great epidemics more readily than other races.

The mortality of cholera, for instance, was so slight that the fact of its existence was even disputed. He attributes the main causes to what he calls "soberness of life," thus interpreted by him—sobriety, better food, carefulness in the rearing of children, thoughtfulness for their aged and infirm, general care of their poor and also of themselves. While in no way disputing the conclusions which Dr. Richardson has arrived at, I venture to assert that most of these beneficial effects have been the results of continuous and unremitting attention to the sanitary and hygienic laws laid down by Moses and amplified by his disciples—laws which, for the first time in the history of the world, proclaimed that "Prevention is better than cure;" that the real science of medicine lay in the direction of prophylactic rather than therapeutic measures. That by the laws he laid down—not as a monopoly for Jews alone, but open to all who desired to live by them, admittedly onerous but undeniably efficient—he not only prevented disease, but if, unhappily, it arose, he took all those measures which modern science has revived to stamp it out.

A PRACTICAL METHOD FOR PREVENTING THE SPREAD OF INFECTIOUS DISEASES IN HOUSEHOLDS.

DR. MALCOLM MCLEAN, of this city, sends us the following practical method of preventing the spread of infectious diseases:

"For ten years past I have been experimenting with a simple method of quarantining cases of smallpox, scarlatina, diphtheria, measles, etc., and, as I have been able to get positively valuable results, I take the liberty of presenting it, simple as it is, to the profession for their trial. My plan consists simply in *filtering the atmosphere* which surrounds the patient through a carbolized or otherwise disinfectant sheet of muslin, which is closely tacked over the door-frames of the room in which the patient lies. I close all unnecessary doorways by tacking the sheet *all about* the frame, bottom, top, and sides. The *one* door which is needed for ingress and egress I protect by tacking a similar sheet across the top, down the whole side of the hinge side of the doorway, and down the lock side as far as within five feet of the floor. This filtering-sheet is made long enough to hang closely to the frame, and fall in folds upon the floor, where it is not tacked. By keeping such a sheet sprinkled with a solution of carbolic acid—I generally use Squibb's two per cent. solution—or other reliable disinfectant fluid, all, or nearly all, of the air of the infected room is *filtered* through a tissue which seems to *destroy the infection in its passage.* Moreover, the filter acts by moral effect, for it happens that intruders into the sickroom are very rare; and thus a great danger and prolific source of the disease is practically removed. Indeed, the whole household are reminded that there is a something within to be avoided. Of course the nurse must use care not

to allow anything to be removed from the room in a condition to carry the poison without.

"After a fair trial of many years, assisted also by several of my brother practitioners (among whom I may mention Drs. I. B. Read, F. A. Smith, and J. A. Walther), I am able to state that, in a list of about fifty cases carefully observed, I have succeeded, in all but *two*, in confining the infection or contagion to the patient first attacked. In the two instances of failure I had abundant evidence that the quarantine was grossly neglected.

"Dr. F. A. Smith had the kindness to report to me a most interesting test of this method which occurred in his own hands last winter. In an institution which the doctor was attending professionally a case of well-marked scarlatina broke out in the midst of scores of young children who slept in the ward. The case was removed to the nurse's room, and there quarantined by means of the filter, according to the method described above. The consequence was that not another case occurred in the institution. On other occasions, where the usual modes of isolation were alone adopted, the same institution had been swept with epidemic force. Dr. Smith expressed to me his belief, founded on experience, that, without the method mentioned in the case reported, he would have had scores of cases on his hands in a fortnight.

"The simplest way to sprinkle the sheet is to pour the disinfectant solution in a flat dish, and dip a hair-brush in it, and with this throw the liquid over the filter. There are three positive points gained by using this method: 1st. The air of the sick-room is not mixed with the air in the rest of the house. 2d. Visitors are much less likely to visit the sick-room. 3d. The air of the sick-room is kept more easily at an even temperature.

"In all of my cases I have found it unnecessary to close the ordinary door, the filtering sheet taking its place."—*Medical Record*

FILARIA SANGUINIS HOMINIS.

In the twenty-first issue of the Chinese Customs Medical Reports Dr. Myers records some further interesting observations concerning the filaria sanguinis hominis, made in the island of Formosa. It seems that although this island is only separated from the mainland, where filaria disease abounds, by a channel 180 miles wide, three cases only of elephantoid disease have presented themselves in nine years among 15,000 general hospital patients, and the three filaria-infested persons Dr. Myers saw all came from the mainland (Amoy and district). This fact—that the disease does not spread in the island, as Manson conjectured it might have done into Barbados—is the more remarkable, as communication with the mainland is constant, and there is an abundance of mosquitoes, so that Dr. Myers surmises that the particular species of mosquito which is the true intermediary host of the filaria exists on the mainland, and probably not on the island. He is at present carrying out a systematic investigation of the different species of mosquito. First, Dr. Myers put a conveniently willing and infected man to sleep in a gauze-covered mosquito house, into which he turned mosquitoes collected promiscuously from all parts of Formosa. These gorged insects he examined day by day, and found that the next morning after their feed they contained several lively embryos, which at later date became digested, and had evidently not got into their true host, for Manson has found that mosquitoes containing filaria sanguinis hominis, when fed on an infected dog, digested the filariæ of the latter. Secondly—Dr. Myers has also made some observations on the periodicity of the appearance and disappearance of the filariæ embryos in respect of the blood circulation in the case of a man suffering from glandular swellings and recurrent lymphatic fever, but otherwise healthy. The tables given show a result in complete accord with Manson's observations. The embryos appeared in the blood circulation regularly between 6 P.M., and 8 P.M., generally a little after 6 P.M., and were present in greatest numbers about midnight, after which they gradually decreased, and pretty well disappeared by 6 A.M., to 8 A.M. This period of twelve hours is just the time that, as Manson has shown, the mosquito is in active search for food. Thirdly—Dr. Myers tries to make out what becomes of the embryos when they disappear from the blood circulation, whether this disappearance is final as regards the swarm, and caused by death, or whether they only lie dormant for the time, perhaps in some viscera, as the lungs. He made prolonged and careful observations on the condition of the embryos at the times of their appearance in the circulation and their disappearance, and he found that the most marked and unmistakable contrast existed between their excessively active vigorous condition at the former time and their increasingly torpid and feeble, shriveled, straightened-out state at the latter time. He thinks the disappearance is final as regards the swarm, and he further argues that unless the parent or parents breed only once or at long intervals, the circulation would get almost blocked by the myriads of filariæ if there were not some more wholesale method of removal than mosquito sucking. Dr. Myers suggests the possibility of the diurnal solution of dead embryos. Fourthly—Dr. Myers watched the behavior of the embryos with such substances as bisulphate of quinine, salicylic acid, arsenious acid, and santonin. The quinine affected them most, but the upshot of the matter is that the quantity of any of these substances necessary to kill the embryos would kill the host also. The problem, therefore, seems to be how to diagnose the exact situation of the parent worm (generally lying in the superficial glands) with an accuracy sufficient to extract it.—*Lancet.*

THE VAPOR-DENSITY OF IODINE.

By M. BERTHELOT.

THE laws of Dulong and Petit, of Gay-Lussac, and of Mariotte, constitute the sole scientific base upon which rests the physical determination of molecular weights, and consequently the numeration of the atoms in present theories. In case these laws should not hold good for certain elements the physical definition of the molecular weights of their atoms would become mere conventions. The author has already shown that the experiments of MM. Kundt and Warburg, on the speed of sound in mercurial vapor, are irreconcilable with the totality of the three fundamental laws above mentioned. The experiments of M. V. Meyer, on the decrease of the gaseous density of iodine and the halogens, under constant pressure, but at temperatures widely remote from each other, are still more contrary to the admitted laws. The only law absolutely and universally applicable to the elements is the invariability of the relations of weight, according to which they combine. This notion and that of the energy brought into play in their reactions are the sole firm foundations of chemical science.

ON THE PURIFICATION OF GAS BY AMMONIA.

By F. D. MARSHALL, Engineer and Manager of the Danish Gas Company, Copenhagen.

As the formation of a company (a prospectus of which appeared in your issue of the 6th ult.) for working the "ammonia soda" process in conjunction with gas manufacture appears to be a *fait accompli*, and as the objects of the company are of universal interest, it may be worth while to consider more fully the details of the process.

In the first place, we may feel sure that the validity of the scheme will receive the fullest and most impartial consideration from Mr. G. Livesey; and, knowing this, one feels a little diffidence in remarking that the published results of the experiments by Professor C. W. Heaton are not so full or exhaustive as could be desired, and have apparently only proved that carbonic acid and sulphureted hydrogen are removable by crude ammonia.

It does not appear from the published statements whether the vital question of obtaining mono or bicarbonate of ammonia from ordinary gas scrubbers or washers, in a tolerably pure state, has been satisfactorily accomplished; for it must be admitted that on this depends the success of the scheme, at least the part of it which applies to the production of ammoniacal gas.

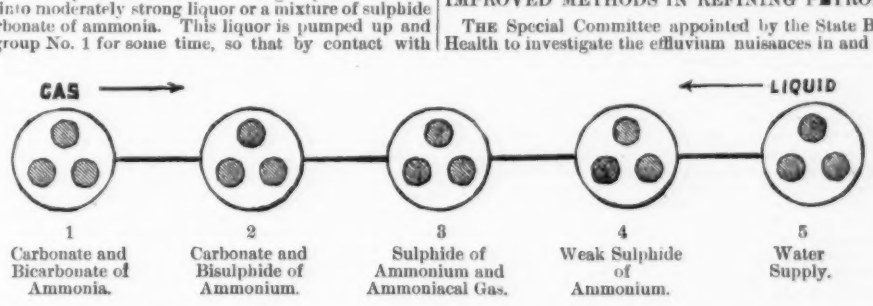
It may be recollected that this process formed the subject of a paper read by me before the British Association of Gas Managers in 1878, and it will be further remembered that, in the process described, it was proposed to employ a series of scrubbers or washers in which the gas is subjected to a process of "fractionation" or divisional scrubbing.

By "scrubbing," in the ordinary acceptation of the term, we imply the removal of impurities—such as ammonia, sulphureted hydrogen, and carbonic acid—by water; and the resultant "liquor," charged with these impurities (both in the free and combined state), is collected in one common vessel or tank.

Now, if we draw off and examine samples of the liquor taken from different heights in its passage down an ordinary scrubber, we should find that it contained the ammonia, sulphureted hydrogen, and carbonic acid in varying degrees of combination; and we should further find that the liquor at the bottom contained a larger proportion of carbonic acid in combination than the liquor at the top of the apparatus. For the liquor, in descending, would absorb carbonic acid in preference to sulphureted hydrogen, which would be continually expelled, and find its way to the top of the scrubber.

By the fractionation process it is proposed to make these reactions apparent, and, instead of using very tall scrubbers, it may be desirable to cut them transversely into sections, placing these sections side by side, and so converting a tall scrubber into a group of small ones, each one of the group having its own receiving tank.

Let us now imagine a series of these groups, numbered respectively 1, 2, 3, 4, 5, in which the gas passes through the series from 1 to 5, while the water or liquid is pumped from 5 to 1; so that by the time it arrives at group 1 it is converted into moderately strong liquor or a mixture of sulphide and carbonate of ammonia. This liquor is pumped up and down group No. 1 for some time, so that by contact with



carbonic acid contained in the crude incoming gas, its sulphureted hydrogen is displaced and pushed forward to groups Nos. 2 and 3, where it is absorbed as sulphide of ammonium. Ammoniacal gas obtained by a subsequent process is pumped into group No. 3, to absorb any free sulphureted hydrogen and sulphur compounds pushed forward from groups Nos. 1 and 2.

On the contents of group No. 1 assuming the desired form of carbonate or bicarbonate of ammonia, they are withdrawn, and subjected to heat in a suitable vessel at a temperature of 180° Fah., and the ammonic carbonate is driven off in a vaporous form to be condensed in another vessel. The residual liquor, after the ammonic carbonate is driven off, is principally water containing a small quantity of carbonate and sulphocyanide of ammonium, and this may be reintroduced into the scrubbers.

So far the process may be conducted in a gas-works, but the following operations constitute the ammonia-soda process, as at work on the Continent, and are preferably conducted in a separate establishment.

(*a*.) The concentrated ammonic carbonate is mixed in a suitable vessel with an equivalent of common salt (chloride of sodium, NaCl)—

$$NH_3CO_2+NaCl=NH_4Cl+NaO_2CO_2$$

Chloride of ammonium and carbonate of soda are formed. The carbonate of soda being soluble would be difficult to obtain as such, but recourse is had to its conversion into an insoluble bicarbonate by an addition of an equivalent of carbonic acid. This carbonic acid in the first instance would be obtained from an extraneous source; but the bicarbonate of soda once formed is eventually heated, and the equivalent of carbonic acid given off is stored for future use. The bicarbonate of ammonia is separated from the chloride of ammonium by centrifugal force.

(*b*.) The ammonic chloride is then heated in a boiler with slaked lime, with the formation of ammoniacal gas, chloride of calcium, and water—

$$NH_4Cl+CaOHO=NH_3+CaCl+2H_2O.$$

The calcium chloride, representing the whole of the lime used, is withdrawn in a soluble form, and may be afterwards employed for sanitary purposes.

(*c*.) The ammoniacal gas, liberated in the last operation, is carried by pipes to the gas-works, and is pumped back into group No. 3, as previously described.

In reviewing the process, it is at once seen that the entire success of the scheme depends upon the production of a carbonate, or preferably bicarbonate of ammonia in the first group; and the statements recently published do not refer to this, or say whether later experiments have been successful in displacing sulphureted hydrogen from a mixture of sulphide and carbonate of ammonium such as gas liquor, and obtaining a tolerably pure carbonate of ammonia.

Referring to my figures and experiments published in the *Journal* of July 23, 1878, it will be seen that we employed scrubbers containing in the first group sulphide of ammonium, and in the second group caustic ammonia, and that by passing crude gas through the series the carbonic acid was absorbed by the sulphide of ammonium, while the sulphureted hydrogen of the ammonic sulphide was displaced and pushed forward to be absorbed by the caustic ammonia in group No. 2. The composition of the ammonic sulphide was—

Ammonia	4·90 per cent.
Sulphureted hydrogen	3·25 "

and assuming the crude gas to contain 4 per cent. of carbonic acid, the theoretical quantity of gas to be passed to convert the sulphide of ammonium into monocarbonate of ammonia would be 39 cubic feet, or into bicarbonate 78 cubic feet.

In our first scrubber, originally containing sulphide of ammonium, we increased our ammonia from 4·9 to 6·89 per cent., and we also found 9·66 per cent. of carbonic acid absorbed.

To convert the 6·89 per cent. of ammonia into monocarbonate of ammonia, it would require 8·9 per cent. of carbonic acid, or a proportion of 22 of carbonic acid to 17 of ammonia; instead of which we have a proportion of 24 of carbonic acid to 17 of ammonia, clearly proving the formation of a bicarbonate of ammonia and a thorough chemical expulsion of the sulphureted hydrogen. For as sulphureted hydrogen cannot exist along with sesquicarbonate or bicarbonate of ammonia except in the free state, the 0·66 per cent of sulphureted hydrogen remaining in the first group of scrubbers must have assumed the free state, and have been held mechanically in solution; that is, about 15 per cent. of the original 3·25 per cent. of ammonia (in the sulphide of ammonium) remained in the free state after all the ammonia had been converted into more than a monocarbonate of ammonia.

These experiments were eminently satisfactory in proving the expulsion of sulphureted hydrogen by carbonic acid from a solution of pure ammonic sulphide. But in substituting ordinary ammoniacal liquor for sulphide of ammonium we could never thoroughly expel the sulphureted hydrogen; and although far more than the theoretical quantity of gas was passed, yet the liquor, on analysis, while containing more than the original quantity of carbonic acid, was largely contaminated with sulphureted hydrogen in both the free and combined state. I am exceedingly anxious to know whether the experiments of Mr. Heaton have in any way advanced this matter, or whether the Ammonia and Alkali Company, when adopting the process on a large scale, intend utilizing another source for the production of ammoniacal gas necessary for the success of the scheme.—*Journal of Gas Lighting.*

IMPROVED METHODS IN REFINING PETROLEUM.

THE Special Committee appointed by the State Board of Health to investigate the effluvium nuisances in and around Hunter's Point, Newtown Creek, and the water fronts of New York, Brooklyn, and Long Island City, have reported a marked improvement in the methods of the petroleum refineries. The committee say:

We visited each of the twelve great oil refineries, and found that the guarantee given by Mr Henry H. Rogers for the twelve refineries, on the 29th ult., in the name of said several refineries, promises to conduct the business of refining oil in such a manner as not to produce noisome or offensive smoke or smells; to prevent the open exposure of spent or sludge acid at any place within fifteen miles of any city in the State of New York during the warm season, or within eight miles of any such city during the cold season; also that such impure acid shall not be allowed to flow, leak, or waste into or upon the ground or streams; also, that cokes, tarry or oil wastes, used as fuel, shall be so perfectly consumed that no hurtful or offensive smoke or stenches shall be produced, and, finally, that the business of the refineries shall be so conducted as to prevent any just cause of complaint on account of any noxious or offensive smells produced by them in any manner. This had been in process of fulfillment, with the following results:

First.—As regards offensive smoke and vapor from firing where a few months since numerous lofty chimneys were pouring forth black, smoky vapor, laden with offensive gases, destined to be wafted for miles, to the annoyance and discomfort of the people of the environs, we found the process of firing going on without smoke. Great care had been taken in the management of the stoking, and a minute and careful supervision had been exercised over those whose duty it is to keep the fires fed with fuel. It seemed to the committee that the smoke nuisance had been almost, if not wholly, abated.

Second.—As to the nuisance heretofore existing from the escape of deleterious and noisome gases into the air during the opening and cleaning out of the stills. By a system of metal hoods and air-tight conduits devised by Prof. H. B. Nason, of the Rensselaer Polytechnic Institute, chemical expert adviser to the refineries, each still as it is opened discharges its gases into these closed tubes instead of into the air, as formerly. These are conducted by means of strong suction to the furnaces, where they are totally consumed without any possibility of their escape into the surrounding atmosphere. It is found that the gases and vapors produced by the opening and clearing out of one still will supply fuel enough to heat one furnace for the space of twenty minutes, thus actually proving of pecuniary advantage to the manufacturers themselves. We regard this system, if properly attended to, as it appears to be, a total prevention of nuisance from the escape of vapor and gases injurious to health during the process above mentioned.

Third.—Spent or sludge acid. We found no evidence that spent or sludge acid was used or manipulated by the oil

refiners. The amount produced by the twelve refineries—some forty-five tons per diem—is pumped into closed, metal-lined tanks or boats, without exposure to the air, and conveyed as often as need be to the distance agreed upon in the guarantee given by Mr. Rogers.

Fourth.—As to the leakage of sludge acid into the ground or into the streams. A system of drainage has been devised, carrying all water impregnated with oily or tarry material through a succession of traps, one lower than the other, partitioned by a number of diaphragms. The oily portion remains on top, being drawn off by a simple system of siphonage, and the water, purified of its harmful constituents, is then allowed to pass into the stream.

THE PRESENT STATE OF THE ROSANILINE QUESTION.

By A. ROSENSTIEHL.

THE rosaniline question has entered upon a new phase. MM. E and O. Fischer have arrived at the conclusion that the three NH_2 groups which exist in their molecules, are, over against the carbon of the methane, in the para-position, and in reliance upon the result of direct experiment they deny the formation of rosanilines, either from a mixture of aniline and of pseudo (ortho) toluidine or from pseudo-toluidine alone. The author takes occasion to distinguish the points upon which he agrees with MM. Fischer, and those which seem to require further examination. The rosaniline which is prepared with a mixture of aniline and ortho-toluidine is always formed in small quantity. In this reaction the aniline plays a part difficult to define, the pseudo-toluidine alone sufficing to produce the red coloring matter. MM. Fischer consider they have proved that its formation is solely due to the presence of a little para-toluidine in the alkaloid employed. The separation of the last percentages of crystallizable toluidine is not effected without extreme difficulty. It is only by submitting the salts and the aceto-toluide to numerous recrystallizations that a point is reached where the colored reactions no longer appear. Such a pseudo-toluidine gives still yields of magenta, varying, according to the success of the process, from 5 to 12 per cent. Admitting that the formation of this rosaniline is due to the presence of para-toluidine (at least 3 per cent. would be required for such a yield), it results that the alkaloid which escapes the action of the arsenic acid (about 40 per cent.) being deprived of its para-toluidine by the first operation would be afterwards unfit for the production of rosaniline. This is not the case. The alkaloid which thus escapes after being freed from small quantities of secondary amines, yields on a second treatment as much magenta as it did the first time. The author has melted pseudo-toluidine which has escaped twice, for the third time along with arsenic acid, and there has been formed as much magenta as before. This production of coloring matter is not due to the presence of xylidine or any other analogous body, for the alkaloid employed had distilled over within the interval of single degree Centigrade. From this series of experiments it results that if pseudo-toluidine, alone or mixed with aniline, gives small yields of magenta, these yields are not null. The author does not think that they are due to the presence of para-toluidine, since from 5 to 7 per cent. of this base would be needed to produce the 15 to 20 per cent. of magenta formed by repeated fusions, which is inadmissible. Either, therefore, the pseudo-toluidine must be transformed during fusion into para-toluidine, or it is capable of forming rosanilines, though to a less degree than its isomer. The author thinks that the conclusion of MM. Fischer, *i. e.*, that the methane of para-toluidine alone is capable of forming rosanilines, is not in absolute agreement with all the facts known. The properties of the different rosanilines are so parallel, as to external appearance, centesimal composition, tinctorial power, and chemical functions, that their non-identity can only be proved by studying the products of their destruction by an energetic reducing agent, hydriodic acid. M. Rosenstiehl considers those rosanilines as distinct which furnish different reduction-products, and inversely. He thus distinguishes para rosaniline, which is decomposed into aniline and para-toluidine from the rosaniline of commerce, which splits up into aniline, para-toluidine, and pseudo-toluidine. All the conclusions obtained by this method are not, however, trustworthy. The toluene red of Coupier is an instance. Its reduction-products are identical with those of common rosaniline, *i. e.*, aniline, para-toluidine, and pseudo-toluidine. Yet it is obtained from materials free from aniline.

ACTION OF OZONE ON GERMS.

By E. CHAPPUIS.

THE author has undertaken experiments to show that ozone has the property of destroying the germs capable of occasioning fermentations, putrefactions, and the development of mouldiness. He has filled flasks with beer yeast, and stoppered them, some with cotton which had been exposed to the action of ozone, and the remnant with cotton not so prepared. The latter became turbid in the course of a few days, while those stoppered with ozonized cotton remained limpid after twenty days.

RESERVE FOR ANILINE BLACK.

By HORACE KŒCHLIN.

IT is known that aniline black is produced directly upon the fiber by printing a thickened mixture of potassium chlorate, aniline hydrochlorate, and a metallic salt. Rosenstiehl has shown that the reaction is due to the influence of the chlorine produced by the decomposition of the chloric and hydrochloric acids. MM. Storck and Strobel proposed to absorb this chlorine by means of ammonium or potassium sulphocyanide, persulphocyanogen being formed. They prove that by printing upon cotton pieces, colors either with albumen, tannin, or aluminum arseniate, mixed in any case with 50 to 60 grammes sulphocyanide per liter, padding in (the materials for) aniline-black, and steaming, the black is not formed where the sulphocyanide has been applied, the latter body acting as a reserve. This process has been in successful action for two years. [A pattern is appended, showing a design with alizarin red and rose and Guiguet's green (albumen), all mixed with sulphocyanide, then padded in aniline black, steamed, and soaped.] Sodium hyposulphite, being an antichlore, acts also as a reserve in the dose of 40 grammes at least per liter of color. Pyrogallic acid, 15 to 20 grammes per liter, also reserves well. The same result is obtained by a process which consists in dyeing the cotton with a manganese bronze, upon which discharge colors are printed, and the bronze is then converted into black by a passage through a salt of aniline. The goods are passed into manganese chloride, then into caustic soda, and oxidized with chloride or chrome. Upon this bronze ground are printed colors containing 400 to 500 grammes per liter of stannous chloride along with the coloring-matter and steamed. The "bistre" styles described by Persoz are thus obtained, and on padding in aniline sulphate the bronze is converted into black. A garnet is obtained in like manner by substituting naphthylamine for aniline.

GELATINE.

GELATINE as a basis for the negative photographic image now holds a place comparable to that which pyroxyline held a few years ago; and in consideration of this fact it becomes necessary for the photographic world, and especially those who are engaged in the manufacture of plates, to take careful note of the general chemical character of gelatine, the manner in which it becomes altered or broken up by various reagents, and other circumstances which attend its reactions.

If a bone is soaked for some days in dilute hydrochloric acid, the whole, or greater part, of the mineral matter becomes dissolved out, and a soft cartilage-like mass, which retains the original shape of the bone, remains behind, this residue constituting the organic or essentially animal parts of the bone. The organic body thus obtained is known as ossein, and although ossein is in itself insoluble in hot or in cold water, it soon becomes changed into gelatine when it is boiled with water. This conversion of ossein into gelatine appears to be unaccompanied by any definite chemical change, the composition of the insoluble ossein and the soluble gelatine being apparently the same, and the following figures represent the composition of ossein or gelatine according to analyses which appear to be reliable.

Carbon	49·2
Hydrogen	7·8
Nitrogen	17·9
Sulphur	0·7
Oxygen	24·4
	100·0

Very many parts of the animal organism are of the same nature as ossein, if not actually identical with it; and among these may be mentioned the so-called connective tissue, the epidermis, tendons, and horn. All these substances are used in the industrial manufacture of gelatine, and the care or skill exercised in the manufacture determines whether the product shall be a fine white and clear gelatine, or the highly impure and partly decomposed product which is sold as a cheap glue.

The following may be taken as a general outline of the principal operations. As it is generally impracticable to use up the raw material as soon as it arrives at the factory, means are ordinarily taken to dry and preserve them, and this is effected by repeated immersions in a thick milk of lime, and drying in sheds specially constructed for the purpose. In this state the materials will keep well, and can be transported from place to place without difficulty or fear of nuisance. The next step is to re-dip into milk of lime, and when the dried animal matter has become softened, the lime which adheres to the surface is rinsed away, and the materials are exposed for some days to the air, in order that any lime which may have penetrated into the interior may become converted into carbonate by the absorption of carbonic acid from the air. In some cases a weak bath of chloride of lime is used at this stage, in order to partly bleach the animal matters. The still damp and soft materials are next boiled in water until those parts capable of transformation into gelatine have dissolved. In order to facilitate the removal of insoluble residues, which always remain behind, the skins and so forth are contained in a kind of metal colander which fits into the boiler, and can be lifted out at pleasure.

Two methods of clarification of the hot liquor are in use, alum being generally used when there is sufficient lime in the gelatinous solution to render it decidedly alkaline; and albumen is ordinarily employed when the solution is neutral or slightly acid. When alum is used, about one ounce is added to each hundredweight of hot solution. The reaction of the lime and the alum causes the deposition of a precipitate of mixed sulphate of lime and alumina, which precipitate carries down various impurities with it, five or six hours being ordinarily allowed for the hot solution to settle. When albumen is used, it is stirred into the hot solution, and, in coagulating, it carries the impurities to the surface.

The gelatinous solution is, in this country, usually allowed to set in flat receptacles, tables covered with plate glass being used for the finer kinds; while in France it is usually allowed to set in large rectangular moulds, the blocks thus obtained being afterwards cut into leaves or flakes. In any case, the flakes are spread on nets to dry—the operation of drying being one requiring the exercise of the greatest care and judgment.

The following method of purifying a commercial gelatine is so effectual that a highly satisfactory article can be obtained from the crude and impure gelatine sold as a low-priced glue.

The solution is allowed to gelatinize, and the jelly is cut up into fragments, and tied up in a coarse cloth. This is next placed in frequent changes of water which is slightly warm, but not hot enough to dissolve the bulk of the jelly. After the greater part of the coloring matter has been dissolved out in this way, the residual jelly is dissolved and strained; its own bulk of alcohol being then added. A clot of very pure gelatine is now thrown down.

Moist gelatine rapidly decomposes and putrefies in the air, but the addition of carbolic acid, alcohol, or ammonia, tends to prevent this. When subjected to dry distillation gelatine yields carbonate of ammonia and various basic oils. When boiled with water it is gradually changed into a body having nearly the same composition as gelatine, but soluble in cold water, this being usually called meta-gelatine. Cold sulphuric acid converts gelatine into leucine, glycocine, and other products, while hot nitric acid oxidizes it, oxalic and saccharic acids being formed as principal products.

A substance very similar to gelatine, and known as chondrine, is obtained by boiling cartilage or imperfectly formed bone with water, and it differs from true gelatine by the fact that it is precipitated by alum, acetate of lead, and the sulphate of iron or copper. It is well suited for making carbon tissue, and it forms the base of the so called grenetine, this being a high-class product manufactured by M. Grenet of Rouen, from cartilage and the skins of young animals.—*Photo. News.*

ON ALMEIRA GRAPE JUICE.

By J. CARTER BELL.

THE juice is from grapes grown during the year 1881:

Specific gravity of juice	1069
Total acid in 100 c.c. calculated as tartaric acid	0·60
Total ash from 100 c.c.	0·312
Per cent. of ash soluble in water	83·08
" " insoluble in water	16·92

CHIEF CONSTITUENTS IN ASH FROM JUICE.

	Grs. in gall.	Per cent.
Potash	113·047	51·730
Soda	4·450	2·036
Sulphuric acid	22·018	18·286
Chlorine	0·692	0·317
Phosphoric acid combined with alkalies	10 888	4·999
Lime	3·825	1·750
Magnesia	8·355	3 823
Phosphate of iron	0·224	0 102
Phosphate of alumina	0·336	0·153
Phosphate of lime	17 472	7 995
Silica	0·280	0·128

—*Analyst.*

THE APPERT PROCESS.

APPERT was a French scientist, who in 1810 discovered that articles of food and other putrescible substances, if hermetically sealed in metallic or vitreous (glazed) vessels, and subjected to boiling heat for a sufficient time, would remain sweet indefinitely. For this discovery Napoleon rewarded Appert out of the French Treasury, and the process was patented in England in the name of Durand. It has been lately claimed—nor has the statement been successfully opposed—that Appert understood the entire subject in all its bearings, and that nothing has been added to the knowledge exhibited in his process from that day to this. The process may be carried out in two ways, one of which is to seal up the vessel hermetically and subject it to heat, and never open it until the contents are to be used, and the other is to permit the air and a portion of the steam generated by the heat to escape out of an aperture left or made in the vessel, and afterward hermetically sealed. The Appert process is, in fact, the process of putting up goods in hermetically sealed cans. The above facts have been repeatedly stated by Mr. E. N. Dickerson, who has been counsel for the defendants in various cases where it has been sought (always unsuccessfully) to establish an exclusive right to the use of the process.

NOTE ON THE EFFICIENCY OF CENTRIFUGAL MACHINES FOR THE SEPARATION OF CREAM FROM MILK.*

By ALFRED SMETHAM, F.C.S.

THE application of centrifugal force to the separation of cream from milk is not new to the scientific world, and analyses of the skim milk so obtained have already been published; but as I have lately had the opportunity of comparing two different forms of apparatus under precisely the same conditions, and have analyzed both the cream and skim milk produced, I have thought that the results might prove interesting.

The two forms on which I experimented were the "Danish" and the "Laval." The former is a recent invention, and was only introduced into England in July last, when it was exhibited at the Royal Agricultural Society's Show at Derby; while the latter is comparatively well known, and has been in use for several years.

The "Danish" has an advantage in the fact that the tube by which the cream is conducted after separation is adjustable (whereas in the "Laval" it is fixed), and cream can therefore be obtained of any density—no matter at what rate the separation is taking place. The difference is clearly marked in the following analyses, which were obtained from two portions of the same delivery of milk:

	"Laval," Running 29½ gals. per hour.	"Danish," Running 49½ gals. per hour.
Water	61·46	52·32
Fatty matters	33·44	42·68
Casein, albumen, and milk sugar	4·56	4·42
Mineral matters	0·54	0·58
	100·00	100·00

The skim milk obtained at the same time had the following compositon:

	"Laval," Running at 29½ gals per hour.	"Danish," Running at 43½ gals. per hour.	"Danish," Running at 52¼ gals. per hour.
Water	91·72	91·82	91 36
Fatty matters	0·29	0·11	0·44
Casein and milk sugar	7·22	7·32	7·41
Mineral matters	0·77	0·75	0·79
	100·00	100·00	100·00

The power was unfortunately deficient, and it was found impossible to run the machines at their full speed; but, notwithstanding this drawback, it will be observed that the results in both instances were highly satisfactory.

There can be no doubt that by the aid of these machines the cream may be practically all removed—far more completely, in fact, than by the ordinary method of setting; and as, moreover, the cream and skim milk are perfectly fresh, it will be apparent that in large dairies (especially those which supply towns) their use will become almost a necessity.

* Read before the Society of Public Analysts, on 16th November, 1881.

ACTION OF CHLORIDE OF LIME UPON THE ALCOHOLS.

IN this memoir the author examines the action of chloride of lime upon ethylic alcohol in equivalent proportions. In a former volume (19, p. 393), the author describes the production of a greenish yellow oil, which on exposure to light or heat explodes, giving off chlorine, hypochlorous acid, and hydrochloric gas. He next describes the action of lime upon monochloracetal, upon alcohol in other proportions, upon dilute alcohol, upon chemically pure methylic alcohol, and isoamylic alcohol.—*Dr. A. Goldberg—Prakt. Chem.*, 1881.

THE INFLUENCE OF ATMOSPHERIC RAREFACTION ON THE ILLUMINATING POWER OF GAS.

At the last meeting of the Société Technique de l'Industrie du Gas en France, M. Brémond, the Chief Engineer of the Madrid Gas Works, contributed a paper on the influence of the rarefaction of air, of barometrical pressure, and of temperature, upon the illuminating power of gas. These meteorological influences have not previously, to our knowledge, been treated precisely in the same way as they have been by M. Brémond, who, it is natural to suppose, has been impelled to study the subject by the conditions of gas supply prevailing in Madrid, which is the most elevated capital city in Europe. M. Brémond first wrote on this subject two years ago, when his observations had simply led him to remark that "the illuminating power of the same gas varies according to the pressure under which the combustion takes place." The last communication is a complement to the former one, and it states the result of M. Brémond's experiments, undertaken in the interval, with the clearly defined purpose of elucidating the conditions of the phenomenon previously generally observed by the author.

M. Brémond remarks that all physical phenomena are modified proportionately as barometrical pressure diminishes. Thus in Madrid, where the gas-works are situated at the height of 610 meters (nearly 2,000 feet) above the level of the sea, it is necessary to correct the thermometer, and not to make use, in exact experiment, of those constructed in Paris. Water boils in Madrid at 97·6° C. of a thermometer graduated in Paris, and this should therefore be the point 100° of thermometers in use in Madrid. The temperature of melting ice is also different at the two places, which affects the position of the zero point of the thermometer. The phenomena of acoustics differ in the two capitals; the resistance of the air to the passage of projectiles is sensibly less in Madrid, and the action of respiration is easier, but also more rapid, in the Spanish capital than in Paris. This concatenation of phenomena—the one class obeying the less density of the air, and the other pointing to the diminished quantity of oxygen in a given volume of air—led M. Brémond to infer a similar effect upon the illuminating power of gas.

Initial Value.	Temperature Deg. C.	Name of City.	Altitude above Paris.	Mean Barometrical Pressure.	Coefficient of Barometrical Pressure.	Illuminating Power in Proportion to Paris.	Reduction due to Rarefaction of Air.	Actual Illuminating Power of Gas in comparison with Paris.	Percentages, Paris Gas being = 100.
105	15·5	Paris.	0	0·754	—	—	—	105	100·00
105	15·5	Vienna.	68	0·747	993	104·26	1·30	103	98·09
105	15·5	Moscow.	235	0·732	977	102·58	3·66	99	94.28
105	15·5	Madrid.	573	0·705	940	98·70	11·00	87	82·85
105	15·5	Mexico.	2212	0·572	710	74·55	44·00	30	29·52

This fact is not in itself a new discovery. M. Brémond, in his first communication, cited the experiments of Dr. Frankland on the influence of barometrical pressure on the combustion of inflammable bodies, and it is well known that in the closed caissons of bridge foundations, under a pressure sometimes of two atmospheres, the lighting effect of any combustible is greatly superior to that furnished by the same source in the open air. It is equally well known that the higher the pressure above the atmosphere at which gas burns the less light it gives; and it is one of the causes of the great advantage of the Siemens burner that it burns at a pressure almost equal to that of the atmosphere. What, then, is the law of diminution of the illuminating power of gas proportional to the rarefaction of the air? Simply this: In consequence of the rarefaction of the air, gas loses at least a liter of illuminating power for each fifty meters of altitude.

The meaning, in English measurement, of the foregoing expression will become clearer if we follow M. Brémond's experiments by which it was determined. These experiments were of the following order: The Northern Railway of Spain, on the road from Madrid towards France, attains considerable altitudes, and at a station called La Cañada, which is the culminating point, it reaches the height of 1,373 meters (about 4,500 feet) above the level of the sea. M. Brémond made a journey along this line, taking with him a supply of gas in holders; these allowed the gas to dilate, following the diminution of barometrical pressure, while the movement of the train spilled the water from the tanks and allowed the gas to escape. This experience counseled M. Brémond to take further precautions to avoid failure; while his experiments, although naturally inconclusive under the circumstances, sufficiently showed that this extra trouble would be worth taking. He, therefore, with the co-operation of M. Barat, the manager of the railway, obtained a special train, and fitted up a goods van with the necessaries for the experimental trip—consisting of two metallic reservoirs, each containing about half a cubic meter of gas; cans containing 500 liters of water; a Dumas and Regnault's photometer (which was found to be useless in consequence of the shaking of the van); a Lowe's photometer, constructed by Suzg; a mercurial barometer; a compensated holostetric altimetric barometer, by Maudet; and a set of thermometers.

From Madrid to La Cañada six experiments were made with each reservoir of gas, which contained gas of different qualities, the one being equal to 95 and the other to 105 liters per Carcel at the time of departure of the train at 5 A.M. These reservoirs were constructed on the principle of displacement, water having the temperature of the van being introduced to replace the gas taken off, which was led to the photometer in leaden pipes without any India-rubber joints. The gas was therefore not submitted to any influence other than that of the rarefaction of the air, since it could not dilate on account of any diminution of atmospheric pressure, or because of the increase of temperature.

The experimental train, which was composed only of three wagons, was stopped at the stations, and the period of stoppage was devoted to photometrical observations. It is unnecessary to repeat the detailed record of these observations, but they may be briefly described in M. Brémond's words, as showing pretty conclusively that the loss of illuminating power due to the rarefaction of the air augments as the altitude increases. M. Brémond contends that this result is quite independent of the influence of barometrical pressure and temperature in dilating the bulk of the gas itself, since by its inclosure in a rigid metallic vessel, displaced only by the admission of water, which was the same in amount at all recorded temperatures and altitudes, dilatation of bulk, save at the point of ignition, was rendered impossible. The net result of these experiments convinces M. Brémond that for every 50 meters (164 feet) above the sea level, gas loses at least a liter of illuminating value; that is, an additional liter of bulk is required to give the illuminating power of one Carcel lamp. For example, in Madrid, which is at a height of 600 meters (nearly 1,970 feet) above the level of Paris, the same gas if of 105 liters illuminating power in Paris, will have in Madrid 105 — 12 = 93 liters. Applying the correction due to barometrical pressure, the temperature of the two places being equal at the moment of the experiment, gas of 1·5 liters power in Madrid is to be multiplied by the coefficient 940, which gives 98·70 liters as the value of the gas in Paris. If this difference is again reduced by the 12 liters lost by the rarefaction of the air, it appears that the gas which gives 105 liters in Madrid is the same which, by the tariff of charges, would be known in Paris as gas of 86·70 liters. This figure is correct, for it is on record that M. Claudio Gil, at Barcelona, with the same coal and cannel, mixed in the same proportions as in Madrid, produced gas of 87 liters per Carcel, measured by the same photometer as in use in Madrid. And the gas taken by M. Brémond to Bilbao, which there registered 80 liters, was indicated as being 94 liters to the Carcel in Madrid, the same photometer being used in both cases.

To show the practical bearing of this principle, M. Brémond has constructed the following table with reference to cities situated at different altitudes:

In Mexico, therefore, a Siemens burner consuming 1,600 liters (56·48 cubic feet) of gas per hour of the quality recorded in the above table, and attaining the light of a Carcel lamp to every 33 liters (1·1649 cubic feet) of gas consumed will only give the total illuminating power of 15 Carcels, while under similar conditions in Paris it would give the light of 50 Carcels.

To the English reader, accustomed to the measurement of the illuminating power of gas by a method in which the *quantity* is fixed while the number of candles varies, the French method of valuation by the quantity necessary to give a fixed illuminating power, as employed by M. Brémond, is slightly awkward. Gas of the quality mentioned in the table, which is called by M. Brémond "105 liter gas"—*i. e.*, 105 liters, or 3·706 cubic feet, give the illuminating power of one Carcel, or 9·5 candles—is therefore of the quality which in English measure would be called 12·81-candle gas. In order to avoid the necessity for the translation of all M. Brémond's data, we have appended the last column of percentages in the table, which, therefore, shows the relative illuminating power of gas in the different places mentioned, whatever may be the method of estimating the illuminating power. It is thus shown that, accepting M. Brémond's experiments as conclusive, a certain identical coal or cannel will only give in Mexico 29·52 per cent. of the illuminating value in pounds of sperm that will be obtainable from it in Paris. The general expression, in English units, of M. Brémond's rule for determining the loss of illuminating power of coal gas due to rarefaction of the air in consequence of altitude, *irrespective of barometrical corrections*, is therefore as follows: *The illuminating power of gas of any given quality diminishes by 0·742 per cent. for every 100 feet of altitude.* The importance of a determination of this kind, in view of the establishment of gas-works at various altitudes, is undoubted, and M. Brémond deserves much credit for the trouble he has taken to work out these results from the observations of practical working under the trying conditions described in the early part of this article.—*Journal of Gas Lighting.*

PHOSPHORESCENCE

By J. CHAPPUIS.

PHOSPHORUS in an atmosphere of pure oxygen is not luminous, but the introduction of a bubble of ozone sets up phosphorescence for a moment. Oil of turpentine prevents phosphorescence, and it possesses the property of destroying ozone. The illumination of phosphorus in oxygen by means of ozone is a means of detecting the presence of the latter.

[JOURNAL OF THE BRITISH DAIRY FARMERS' ASSOCIATION.]

REPORT ON CONDENSED MILK.

By DR. AUG. VOELCKER.

THE majority of the samples sent in for competition was condensed milk, obtained by evaporating milk partially skimmed, at a low temperature, and with the addition of white refined sugar. A few exhibits were unsweetened milk, or milk evaporated to a certain consistence without the addition of sugar.

UNSWEETENED CONDENSED MILK.

The following is the composition of three samples of such unsweetened condensed milk:

	No. 1.	No. 2.	No. 3.
Water	56·96	56·92	51·72
Pure butter fat	16·02	17·09	14·33
Casein (curd)*	8·50	7·62	11·69
Milk sugar	16·32	16·22	19·51
Mineral matter ash)	2·20	2·15	2·75
	100·00	100·00	100·00
* Containing nitrogen	1·36	1·22	1·87

Two of the samples, it will be seen, contained 67 per cent. of water each, in round numbers. The proportions of water left in these samples appear to be far too large to prevent the condensed milk turning sour on keeping.

On opening one of the tins in which the milk was sent in for competition, the condensed milk was found in an active state of fermentation; and the two other samples turned acid and entered into fermentation the day after opening the vessels in which they were contained.

In the preparation of these and the sweetened samples of condensed milk, neither boracic acid, borax, or preparations containing boracic acid (glacialine), nor salicylic acid or other preservative agents, had been used.

CONDENSED MILK (SWEETENED)

The following is the composition of condensed and tinned milk, in the preparation of which white sugar has been used:

	No. 1.	No 2.	No. 3.	No. 4.	No. 5.
Water	21·68	23·49	22·45	24·53	23·49
Pure butter fat	9·92	6·47	10·60	6·22	9·53
Casein (curd)*	9·19	9·27	8·82	9·44	7·43
Sugar	56·98	58·66	55·96	57·72	57·34
Mineral matter (ash)	2·23	2·11	2·17	2·09	2·21
	100·00	100·00	100·00	100·00	100·00
* Containing nitrogen,	1·47	1·48	1·41	1·51	1·19

All the samples were well-made condensed milk. Such condensed milk will keep for any reasonable length of time. The proportions of water in the various samples varied from 21½ to 24½ per cent. in round numbers. Milk evaporated to an extent as to leave in the finished tinned milk 25 to 26 per cent. of water, according to my experience, is sufficiently concentrated to keep well if otherwise carefully evaporated with the needful proportion of best white sugar.

Two of the condensed milks, it will be seen, contained respectively 6¼ and 6½ per cent. of pure butter fat; the remaining samples from 9½ to 10½ per cent.

All the samples of sweetened condensed or tinned milk sent for competition were in excellent condition; they were all readily soluble in hot water, and produced, when sufficiently diluted with water, agreeably tasting, sweet, milky liquids. As regards taste and flavor, and miscibility with water, there was little to choose between the different samples sent in for competition; in fact, the condition and quality of most of the samples were so much alike that it was not easy to decide to which kind preference should be given.

The quality of condensed milk, in my judgment, depends more upon delicacy of flavor than upon the proportions of butter fat (cream) which occur in different samples—that is to say, condensed milk comparatively poor in fat may be, and generally is, preferred by the consumer to condensed milk richer in butter fat.

Not unfrequently condensed milk is represented to be nothing more or less than new milk evaporated, at a low temperature, to a certain degree, with the addition of white sugar. None of the five samples analyzed by me, however, were produced from whole new milk, but from more or less skimmed milk.

If milk rich in cream is evaporated to a small bulk, even with the greatest care, the resulting condensed milk, when mixed with water, draws up oily globules, tastes somewhat rancid, and not so nice and sweet as condensed milk produced from partially skimmed milk.

Really good condensed milk, as a matter of fact, is always made from skim milk, or from milk unusually poor in cream.

In the form of the well-known thick honey-like preparations, condensed sweetened milk is a useful article of food on board ship, or under all circumstances when fresh milk cannot be procured. It certainly is preferable to milk powders, obtained by evaporating skim milk completely to dryness, and with the addition of some sugar, reducing the residue to powder.

However, apart from the greater price of condensed milk, it is not a perfect substitute for new milk, either chemically or physically. At the best, most kinds of good condensed milk are milk syrups, consisting of concentrated skim milk and white sugar.

THE NATURE OF SWAMP MUCK AND ITS VALUE IN AGRICULTURE.

By DR. JAMES R. NICHOLS.

THE general term, *muck*, has been given to those deposits of dark vegetable matter stored in low bogs and meadows, and in the bottoms of ponds found upon many farms in the Northern States. The term is, perhaps, as good as any that may be suggested, although it does not convey a clear idea of any special kinds or varieties, of which there are many. The name *peat* better distinguishes the deposits in most bogs and meadows, but is not applicable to those of frog ponds, and larger basins of water. If the meaning of the word *muck* could be restricted to that class of wet meadow products in which the natural alteration of plant tissues had proceeded far enough to fit them for agricultural uses, it would be a convenience, and remove some confusion which now exists among chemists and farmers. It is not difficult to describe the deposits, or their physical peculiarities, so as to make a clear distinction between what might be called *peat* and *muck*, and in this discussion I will endeavor to point out the distinction.

ORIGIN OF MUCK DEPOSITS.

The origin of the deposits under consideration is not by any means obscure, and may be stated in a few words. Whenever stagnant water has existed in low basins for a large number of years, a certain class of marsh plants, mosses, and grasses have found favoring conditions for rapid and luxuriant growth. These plants have matured and decayed, finding a tomb in the impure waters which fostered their growth. As the decades of years and of centuries succeeded, with the alternations of heat and cold, the basins were filled up, so that surface water disappeared, and matted turf, compacted with low and worthless forms of grasses, came into view. In most cases deciduous trees and water shrubs grew in association with the grasses and mosses, and the annual fall of leaves and dead twigs contributed not a little to filling up the stagnant ponds and puddles.

Whenever vegetable growths become dead and fall into moist earth with access of air, a process of eremacnusis, or slow combustion, commences, which, proceeding slowly, ultimately ends in entire disorganization of tissue, and the product is called *humus*. The process is different when it falls into the water, as in the case of large trees and limbs, a dozen centuries will hardly serve to disassociate and change their cellular structure, and some of the finest and most durable timber used in ship and house construction has been exhumed from the vast swamps and bogs found in our own and other countries. The peats and mucks of our own low meadows, have to a large extent resulted from the decay of the smaller forms of vegetation, as grasses, leaves, and moss. Of all the various forms which have contributed to our muck beds, the spongy mosses constitute, undoubtedly, the most important constituents.

THEIR AGE.

How long a time it requires to form a well advanced muck bed is not certainly known, but under ordinary conditions

a hundred centuries may be required, or even five times that number. The stage of decay in which it is found does not always indicate the lapse of time consumed in the changes, as under favoring conditions of extreme heat, or access of air during frequent low stages of water, the changes proceed much more rapidly. It is probable that no muck deposits on our farms, suited to agricultural uses, can have existed, in their lower strata, less than the time, which, according to the Mosaic record, man has existed upon the earth.

DIFFERENCES IN MUCK.

When these deposits are carefully examined by the eye, they present very marked and important physical differences. In texture and color, no two can hardly be said to be exactly alike. Some kinds consist almost entirely of the withered remains of plants, which have undergone but little alteration, except mechanically; in other varieties, the organized structure of the plant remains more or less distinctly visible; in other kinds, there is no obvious indication of plant structure existing. In the latter variety nothing remains but a black unctuous *mud*, which, when dried, crumbles to a fine dust. I have sometimes found this form of dried muck to be denser than water, having a specific gravity as high as 1·23, but generally it is lower than water, not rising higher than 0·88.

POND MUD, ETC.

It is not necessary, perhaps, to make further lines of distinction in low meadow deposits. As regards pond sediments, they belong to a distinct class of waste vegetable material, although identical, often, so far as the organic constituents go, with bog deposits.

Three forms of meadow deposits have been pointed out; those of the *first class* may be called the *immature* forms, where the constituents are coarse and spongy, with fragments of twigs, rushes, and leaves, seen in distinct outline. In the *second class*, the organized structure of plants can be recognized, but the decay has proceeded so far as to break them up almost into indistinguishable forms. These products are rather light and spongy, but much denser than those of the first class. The *third class* is the black, dense, perfectly metamorphosed humus, with a clayey feel, and when touched, leaves discoloration upon the fingers.

The two first varieties I will designate as *peat*—the last *muck*. All these forms when dried are useful for *fuel*, but not for employment upon the farm, unless possibly as absorbents for liquid manures, as a whole. The two first forms had better be cast out of the category of useful farm agents, and attention only be given to *muck* proper.

MUCK PROPER.

Muck, then, considered as the most advanced of all bog deposits, is easily recognized by its peculiar physical conditions, and is the only substance about which farmers need concern themselves; and it now remains to consider its value, as a manurial agent. The large amount of water mixed with muck in its natural state is a most serious obstacle to its farm employment. It may be stated to hold a minimum of 60 per cent., and a maximum of 92 per cent., the average being, in New England mucks, not far from 85 per cent. of water. To cut out a water soaked substance like this, from a treacherous, spongy bog, lift it into carts, and haul it long distances, involves great labor and expense. If it is allowed to air dry on the spot where exhumed, some advantage is gained, but it must be remembered that under the most favorable weather and conditions for drying, much water remains to be transported. Experiments at my farm upon air dried mucks, extended over five seasons, showed that water remained in the material to an extent varying from 30 to 47 per cent. It is probable that not many farmers have ever seen a specimen of absolutely dry muck; that is, such specimens as the chemist has in hand in making his analysis in the laboratory. The absolute water-free muck is a light substance usually, which the wind will scatter as it does a handful of feathers. When muck is spread upon a field, much of it blows away in the high winds of summer, when it is very dry from exposure to the hot sun. This is a source of loss not usually taken into account. The light mucks oftener belong to the first and second classes, or what I have designated as peats.

CHEMISTRY OF MUCK BEDS.

The chemistry of a muck bed is interesting, and deserves brief remark, although the analysis which I have to present will afford information upon this point It is plain that a substance so under the constant influence and action of water can contain no ingredients *soluble* in that fluid; and hence we fail to find in the ash of muck any of the soluble forms of plant food. None of the valuable soluble salts of potash, soda, or phosphoric acid are present in the muck bed, unless in extremely minute quantities. In soils on higher lands, the humus and ash contain all these soluble agents, derived from the decay of vegetation. It must be kept in mind that vegetation decays *in water* under different conditions from that when exposed to air, or in the presence of oxygen, and a different condition of the resultant mass must be expected.

The greater portion of the inorganic material of muck is lime in its insoluble form, silica, iron, alumina, and often magnesia. Of the alkaline earths, lime is present in greatest abundance. From a careful consideration of the results of analysis of a large number of specimens of muck made during the past quarter of a century, under my observation, I have no hesitation in saying *that the ashes of muck are practically worthless to the farmer as a source of plant food.* I say *practically* worthless; meaning by this, that the inorganic constituents of mucks contain so little of valuable, available, plant nutriment, that if they held no other forms they would be entirely unworthy of attention, even under the most favorable conditions. This view is sustained by the investigations of Kane, Sullivan, Vaux, Regnault, Mulder, Baer, Peterson, Anderson, Wagner, and many other eminent chemists in Europe, and Johnson, Storer, and other chemists in this country; in short it is sustained by the analysis of every competent chemist whose researches have extended in that direction.

NITROGEN IN MUCK.

As regards the other forms of valuable plant food contained in muck, I have only to consider *nitrogen*. All analyses prove the presence of potential nitrogen in mucks, and in some it is found in considerable quantities The form in which it exists is in combination with organic acids, the humic, ulmic, crenic, and aprocrenic. It has been alleged that free ammonia has been found in some bogs, but I have failed to detect it in any specimens coming under notice, and no reliable chemist, so far as I can learn, has declared its presence. Nitrogen is the most costly, and indeed the most valuable, of all forms of nutriment needed by plants, and the question of its value as found in mucks is one of high importance in this discussion.

ANALYSIS OF MUCKS.

In the table of analysis presented below, a clear view is given of the amount found in three typical specimens of muck, one of which is from a bog on my farm at Winnekeni, one from a remarkable deposit in Boxford, Mass., the other from a well known bog at Plaistow, N. H. The equivalent in ammonia (NH_3) is also presented.

	Nitrogen.	Ammonia.
Winnekeni farm, per cent.....	0·56	0·68
Plaistow, N. H., " "	0·31	0·37
Boxford, Mass., " "	0·50	0·61

The above is as found in the *wet* condition. In the *water-free* state it stands as follows:

	Nitrogen.	Ammonia.
Winnekeni farm, per cent.....	2·47	3
Plaistow, N. H., " "	2·13	2·55
Boxford, Mass., " "	2·12	2·59

The average of fifteen determinations of nitrogen in wet mucks, by Prof. Johnson, is,. 0·42
Water-free..... 2·31

It will be noticed that Prof. Johnson's determination shows a little higher percentage of nitrogen in the dry muck, than those which I have presented, but the difference is trifling. Taking muck beds as they are found in the Northern States, it will be safe to assume that they hold on an average, in the absolute dry condition, about two and a quarter pounds of potential nitrogen in each one hundred pounds.

The following table gives the results of the analysis of five specimens of muck, showing the amount of water, organic matter, and ash contained in each :

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Water.....	77·36	85·49	76·46	89·35	36·74
Organic (vegetable and volatile matter)	19·65	14·39	22·97	9·64	5·30
Ash, including sand.	2·99	0·12	0·57	1·01	57·96
	100·00	100·00	100·00	10 ·00	100·00

In No. 5, will be noticed a very great dissimilarity of composition from the others. This specimen was taken from the bare bed of Plug Pond in Haverhill, Mass., and in appearance is densely black, fine, and "well calculated to deceive." From this bed a neighbor had taken many hundred cartloads at great expense, for use upon his farm. It is a specimen typical of usual pond deposits, which are largely employed in agriculture all over the Northern States. They are worthless specimens.

No. 1 is the sample from my farm, from which the nitrogen determination was made, as given above. The amount of lime contained in the ash (not given in table) is 1·7 in the dry state. It is fully decomposed, dark, and every way of excellent quality.

No. 2 is the sample from Plaistow, N. H., and contains a less amount of water, a larger percentage of ash and organic matter than No. 1, but is of superior quality.

No. 3 is from Boxford; contains about the same amount of water as No. 2, much less ash, and more organic matter. The nitrogen contained in the last specimens has been given above.

No. 4 is from a large basin called "Sour Meadow," on the margin of Lake Kenosa, in Haverhill, Mass. This specimen holds nearly 90 per cent. of water, and has but 1 per cent. of ash. It is not well decomposed, having fragments of leaves, grasses, etc., in the mass. The five samples have been selected with the view of presenting the extremes of variation in muck beds which are drawn upon by New England farmers for agricultural purposes. It is now possible to present a clear estimate of the value of the nitrogen in the best specimens. No. 1 from my farm meadow contains in each ton (2,000 pounds), of *water free* muck, 49·40 pounds; this at 15 cents (a fair price), gives a money value of $7·41 for the nitrogen. The value of all the mineral and nitrogenous plant food it contains may be stated as follows :

Nitrogen.....	$7.41
Lime.....	.30
Other salts.....	.10
	$7.81

The cost of procuring one ton of absolutely dry muck may be understood from the fact that *ten tons* of the wet mass is required, estimating the water at 90 per cent., which is a fair average for successive seasons. A ton of wet meadow muck of best quality is thus shown to have a value of seventy-eight cents, as fertilizing material for farm crops, estimating its mineral plant food constituents as we estimate that found in cow dung.

ANALYSIS OF COW MANURE.

With the view of affording a comparison of muck with fresh dung, a sample taken from my barn stalls, the droppings from cows in milk, is here presented. It contained of

Water	81·08
Organic matter.....	15·96
Ash.....	2·96
	100·00

The result of this examination may appear somewhat startling, inasmuch as it shows that the fresh cow dung from the barn contains *more* water and *less* organic matter and ash than is found in the muck on the farm forty rods distant. It would appear (other things being equal) that the muck is as valuable, or even more valuable than the dung, but important considerations come in to dispel this illusion. A complete analysis gave, as contained in each ton of the fresh dung, the following amounts of valuable constituents.

Nitrogen.....	5·11 lb.
Phosphoric acid.....	3·55 "
Potash.....	2 "

The nitrogen in manure has a higher value than that in muck, but estimating it the same, with the phosphoric acid, potash, etc., the value stands as follows:

5 1-10 lb. of nitrogen.....	15	76
3½ lb. of phosphoric acid.....	12	42
2 lb. of potash	7	14
Lime and other salts		33
		$1.65

ANALYSIS OF LIQUID EXCREMENT.

The nitrogenous and mineral value of muck stands to fresh cow dung as 78 cents to $1.65 per ton, water soaked; or nearly three to one in favor of the latter; but it must be remembered that fresh cattle droppings do not represent *manure* as found in farmers' barn cellars. This consists of a mixture of the *liquid* excrement with the solid. A ton of fresh urine, as determined in analysis from specimens collected at my barn, gave the following results:

Nitrogen.....	17·5 lb.
Phosphoric acid.....	10·12 "
Potash.....	15·9 "

This result indicates the very high value of liquid manures, giving a value per ton of about $5.00, the estimate being made in accordance with that for muck and for solid excrement. A ton of well mixed manure, containing equal proportions of the solids and liquids, has a money value of not far from *four dollars*, or, this is the value of the manure stored in the barn cellar at Winnekeni farm, as learned from analysis.

MUCK HUMUS.

Let us look for a moment at the nature and value of the naked *muck humus*, that is, what remains after the separation of the nitrogen and salts, and contrast it with exhausted manure. The humus or "geine," as Dana persists in calling it, which results from the decay or *mouldering* of vegetable matter *under water*, or in moist places, is a very different substance from that which results from the decay or decomposition of hay and grains in passing through the digestive and assimilating organs of animals. It must be admitted that muck very rarely represents merely the mineral constituents of the plants from whose remains it has been formed, neither does its organic portion represent those structures as when changed under other, or usual conditions. In virtue of a kind of dialysis or chemical reaction, not only mineral constituents are changed or abstracted, but vegetable tissues undergo a metamorphosis which renders the changed mass not as well suited as other varieties of carbonaceous material to form fertile soils.

Hay and other forms of food consumed by animals in passing through living organs have their elements so acted upon that they speedily pass into putrefactive fermentation, which breaks down tissues or cellular structures with great rapidity. The catalysis of life impresses a peculiar power upon animal foods and introduces a force of disassociation not noticed in other processes; hence *manure* has properties not found in any substance adapted to the nourishment of plants. Muck humus and dung humus can only be contrasted to the advantage of the latter. The former resists change (necessary change) when applied to silicious soils; and when muck humus is mixed in association with manure, the former is distinguishable on fields often for several years after the latter has gone from sight. In any just and accurate estimation of the comparative value of muck and manure, this important factor must not be lost sight of.

FARM TRIALS OF MUCK.

To present in detail the observations and experiments upon muck, made at Winnekeni farm in the past quarter of a century, would require space only afforded by a large volume. In this paper a brief outline or summary is presented. In trials of muck upon the farm, a systematic plan has been adopted, with the view of securing reliable results, and these show that *muck is not manure* in any proper sense in which that term is used. They further show that the substance cannot be made into manure without an expenditure for added materials, and at a cost of time and labor which do not comport, under usual conditions, with proper farm economy. The simple mixing of lime with muck betters its condition, but it does not change it into manure.

If muck in its partially dried condition is to be changed into a mass, corresponding in some particulars with manure, not only lime, but nitrogenous salts, potash, soda, soluble phosphoric acid, and other less valuable forms of plant food must be added. I have succeeded in forming artificial manures at the farm, using muck as a bulk basis and absorbent, which afforded very gratifying results when applied to growing crops, but the cost rose in all cases in due proportion to its value.

In these experiments the material in hand, to begin with, muck, had a certain known value, and it would be manifestly empirical to expect from the use of that material benefits which it had not the power to bestow. In trials upon fields, in most instances, I have not learned that the raw material, air dried or wet, gave results in increased fertility, corresponding with expenditures incurred in its application. On dry silicious soils it has not supplied the place or served the purpose of natural upland humus. On medium low lands it has rarely indicated through successive seasons any influence for good.

MUCK MEADOW EXPERIMENTS.

A portion of the farm meadow from which muck has been taken was reclaimed and drained a dozen years ago, and nearly a thousand loads of sand carted upon it. This afforded for several years heavy crops of upland grasses; but, like all muck meadows, it requires applications of fertilizers to maintain fertility. The surface soil of a muck meadow is, from obvious reasons, better adapted for plant sustentation than the contents deeper down. Portions of the bog were turned up to light and air from depths of a foot or more, and on this, without sand or fertilizers, potatoes were planted. The crop was a failure, although the season was favorable. Root crops, the cereals, and even the better grasses, do not flourish on a deeply plowed muck meadow, so far as my observation extends, and there is indeed no reason to expect different results. These crops all require potash and phosphoric acid for complete development, agents which are not present except in minute quantities in any muck field. Experiments with muck soils, upon all kinds of plants, in pots, carried through several seasons, have supplied interesting facts, but the statements regarding them must be left for another paper and another occasion.

VIEWS UPON THE VALUE OF MUCK.

The laboratory researches upon muck, undertaken at my farm, of which a brief and imperfect account is here presented, correspond essentially in result with those of Prof. Johnson and all other chemists, at home and abroad, who have entered upon like labors. Such, however, is not uniformly the case with the practical use of the material by farmers in the field. A large number of quite intelligent men declare its influence in the direction of soil improvement to be marked and decisive. Others are so loose and extravagant in their statements of benefit received, as to render them of very doubtful accuracy. Nothing is more deceptive and uncertain than observations upon farm crops, and the

influence of soils and fertilizers, when no careful methods and no weights and measures are employed. The eye, used only in a casual way, in the hurry of farm work, is not a safe guide. Much of the confusion and uncertainty in which practical husbandry is involved, is due to hasty, careless, unmethodical observations in the field. Better methods and more care are desirable.

CONCLUSION.

To sum up the whole question of the agricultural value of muck, it may be said that it is of great value as an absorbent of liquid manures, and where it can be obtained easily, large stores of air-dried muck should be secured and used by every farmer. As an application *alone* to soils of any variety, silicious, dry, humid, or any other, it has a very small value. Its whole contained amount of mineral plant food does not equal in value more than fifty or sixty cents a ton, and the bog humus in which it is involved is of little value except as an absorbent.—*N. E. Farmer.*

SILOS AND ENSILAGE.

"I AM very desirous to become thoroughly conversant with the system of preparing *ensilage*, the mode of construction of the *silos*, the character and quality of the food as it is taken from the *silos*, the cost per ton; its milk and flesh producing qualities, and such other information as might be of service to me as an agriculturist."

The above paragraph, taken from the letter of one of our correspondents in New Brunswick, undoubtedly voices the thoughts of thousands of farmers throughout the United States and Canada. M. Auguste Goffart, an enterprising farmer of France, was the first to bring the system of silos and ensilage to the notice of farmers of the present generation. A small volume of his writings was published in Paris, in 1877, and translated into English, and published, with some additions, by J. B. Brown, of New York, in 1879. In the year 1876, Mr. Francis Morris, of Maryland, received from France a newspaper containing an account of this new method of keeping fodder, and the same year raised a field of corn, which he buried in brick silos for winter feeding. His success was such that the experiment was repeated upon a larger scale the following year. The first silo in New England, so far as we know, was built in the summer of 1879, by John M. Bailey, at "Winning Farm," Billerica, Mass. Dr. Bailey became very enthusiastic in his expectations of what the new system may accomplish for the agriculture of New England and the United States, and by publishing a "Book of Ensilage" and throwing his farm open to public inspection, created an interest in the subject which has been not only widespread, but in many instances almost intense. The statement that by the adoption of this system, wherever corn will produce full crops, milk can be made at a cost of one cent per quart, butter for ten cents per pound, pork for three cents, beef for four cents, and mutton for nothing, when wool sells at thirty cents per pound, is a statement that would be likely to wake up a good many sleepy farmers, and also set capitalists to asking themselves if farming, after all, is not about the best business that the country affords to put money into. As a result, a great many silos have been built within the past two years, both by men of unlimited means and by small farmers, who can not afford to invest very liberally in untried experiments. A few have had an unbounded enthusiasm in the business, while many others have earnestly opposed the system, believing that sooner or later it would cause serious trouble in the herds which are fed upon such an unnatural diet. Others, and much the largest number, have been willing to suspend judgment until full reports could be made by the pioneers in the new enterprise. Several of the agricultural newspapers in the country allowed their columns to be crowded by the ensilage discussion, almost to the exclusion of the more usual topics of interest to farmers in general, while the public meetings of farmers and dairymen have in some cases been the scenes of most enthusiastic arguments and discussion. Some of the scientific men, including chemists and doctors, have predicted a short "run" of the ensilage "fever." They have believed that those who claim so much for the system have been in some way deceived, and that many will be disappointed in their expectations. Dr. Goessmann, of the Massachusetts Agricultural College, delivered a lecture last winter, by which he influenced many to "go slow" in their pursuit after rapid fortunes in this direction. Some have predicted ill-health among the herds fed upon such soft and unnatural food; that the teeth would soon decay and fall out for want of use; that ensilage will demoralize cows as badly as brewers' waste and city swill; that abortion, that most dreaded of all diseases among dairy cows, would be induced, and also that the milk and butter would prove very inferior in quality. It is objected to ensilage that it is nothing but corn fodder at best, and that corn fodder is never a very rich food, any way it may be prepared; and Dr. Goessmann finds by referring to various authorities, that corn, and especially sweet corn, loses a considerable per cent. of its nutrient constituents by fermentation in the silo, while green fodder, dried perfectly in the open air, loses nothing.

The *New England Farmer* published numerous articles upon silos and ensilage when the subject first attracted general attention, but it has never advised its readers to go ahead blindly into this or any other new scheme. We have watched the progress made in solving the silo question with no small degree of interest, knowing that if one-half were true that some of its advocates have claimed, the agriculture of this part of the world must inevitably be revolutionized. A considerable number of silos were built and filled last season, but a great many more this year. The season, however, has not been particularly favorable to the growth of corn, and it is probably safe to say, that most farmers have already come to the conclusion that the average amount of corn that can be grown per acre, one year with another, is considerably less than half what has been claimed as possible, if not probable. There is no difficulty in figuring up seventy-five tons of green fodder, by weighing a few extra large corn plants, and multiplying by the number there would be room for on an acre, provided they would only grow, but the best farmers find it taxes them pretty well to grow twenty five or thirty tons, actual weight. Although all kinds of green fodders may be kept in silos, and in unfavorable weather this may be the best way to dispose of them, yet it seems to be the opinion of the majority of those who have built silos, that they are more specially adapted to Indian corn. The finer, forage crops, like hay, clover, millet, etc., can be cured so quickly in favorable weather, and without losing any of their nutritive value, that the advantages of pitting over drying do not seem very marked.

There is this to be said, however, in favor of silos and the ensilage system, that, so far as we have been able to learn, not a single farmer who has built and filled a silo has been found ready to condemn it or abandon its use, nor have we heard as yet of a single instance of sickness, loss of appetite, loss of flesh, loss of teeth, or a single case of abortion that is treaceable, directly and unmistakably, to the judicious feeding of ensilage. There may have been such cases, but they have not come to our knowledge. A good many silos have been built the past summer, which, owing to the poor corn season, were not filled, the owners not deeming it advisable to procure cutting machines and power for handling so small a crop. We notice, too, that almost every one who makes his first experiment finds that he has made more or less, mistakes, and expects to do better next time, or if to build again would build better, or with more economy. We have visited a silo recently, where water was found standing in the bottom, and the under layer was evidently injured. Scarcely any two silos are filled precisely alike, and it is still a question with many, "Which is the best way?" A silo in Wrentham was examined a short time since, which was filled with field and sweet corn, which had reached that degree of ripeness that allowed of the ears being saved for seed. The field-corn ears, picked off and spread in an upper loft in the barn without husking, were perfectly ripened, firm, and sound, and as bright as the best seed could be. The best ears only were thus picked off and dried, the larger portion being cut with the fodder and put into the silo, and to our surprise the kernels are scarcely changed in color, are but slightly acid, and appear to be as perfect food for cows or horses as one could desire. The fodder as a whole, as now lying in the pit, is apparently equal to any sample of ensilage we have ever seen, and far better than much that has been exhibited. If it proves a fact that the stover of our field corn can be saved in silos instead of drying it in the open air, or still better, if the entire crop can be cut and pitted without serious waste or loss, the silo may eventually become as common as the farm stable. Every report we have received from cows fed upon ensilage shows an increase in quantity of milk, and although many are afraid the quality may be injured, we have as yet heard of no instance where either milk or butter has been condemned as the effect of feeding ensilage judiciously. Most of the reports which have come to us have been of the quantity of milk produced. We know of no farmers in New England who would be less likely to be misled by great expectations or who would look into a new thing with more caution than Messrs. A. H. Thompson & Son, of Hopkinton, Mass., whose farm methods have been occasionally reported in these columns. Their farm is rather light, better for corn than grass, and for many years, corn, both for soiling in summer and dry feeding in winter, has been a leading crop. Their stock, too, has brought large returns in milk, and the Messrs. Thompson have not been the men to grumble of hard times for farmers. They believe the silo has come to stay, and that, before many years, every enterprising farmer will feed from one during the winter. In a letter received near the close of the feeding season last winter, they write as follows:

"We are feeding ensilage to our milch cows this winter, with very satisfactory results; the cows are giving from one to two quarts more milk a day this winter than they ever gave before, at any time of the year, when we practiced the soiling system in summer and dry feed in winter, with a liberal feed of grain and roots, which we used to think was the best way then in use. We are feeding less grain this winter, with ensilage; 5 pounds of cottonseed meal to a milch cow per day; when we fed dry feed, we fed the same of cotton seed, with about 4 to 8 quarts of shorts, or 2 to 4 quarts of cob meal. An average cow will eat about 60 pounds of ensilage per day, which costs us this season about $2.50 per ton in silo."

At a subsequent interview the following statement was made:

"Our cows will eat in summer, of green corn fodder, a hundred pounds per day, and seem less satisfied than with the sixty pounds of ensilage. They eat less grain with ensilage, and give more milk than when fed green corn."

Their explanation is, that the ensilaged corn is partially digested in the silo, and really affords the cow more nutriment than the raw corn, Dr. Goessmann's conclusions to the contrary notwithstanding. The opinion of the cow, as shown in her yield, health, etc., must, after all, be taken in preference to the predictions of either chemists or physiologists.—*New England Farmer.*

ENSILAGE IN NATURE.

THE STOMACH OF A RUMINANT A SILO IN MINIATURE.

THE anatomical construction of ruminants, notably their stomachs, indicates that their natural diet is bulky, green herbage, designed to be swallowed rapidly, and with little mastication, into a capacious reservoir, to remain till the animals have time to retire to some place of rest and quiet, to pulverize the half-ground mass by thorough mastication. But this is not the only purpose served by holding green food in a huge sack for several hours before discharging it into the division of the compound stomach for digestion proper. A mass of succulent matter packed in a wet and warm place will soon ferment and become sour. In the stomach, lactic acid begins to form very soon after the bruised herbage is swallowed. Though this is generally regarded as forming no part of actual digestion, it is not without some bearing upon it. Herbaceous food always abounds in crude, woody fiber, which, when it enters the stomach, is indigestible from being insoluble, and in this condition is useless as food. If it could be digested, it would serve the same purpose that is served by its more soluble associates, starch and sugar. By souring, some of such fiber is rendered soluble and digestible, and thus increases its food value. To the greater extent to which this action upon fiber goes on in the stomachs of ruminants above that of non-ruminants may be ascribed the better results of feeding herbaceous food to the former.

An evidence of the more complete digestion of woody fiber in ruminants than non-ruminants, may be seen in the condition of their respective solid excrements. For example, take those of a sheep and a horse. In those of a sheep the fiber is almost exhausted, while in those of a horse it is so little affected that it constitutes the great bulk of the offal. In this respect the cow also makes better use of fiber than the horse. As a green and coarse state seems to be the natural condition for ruminants to receive their food in, it would be very desirable to furnish it to them in that state the year round, but where six months of the year are winter, this is difficult. To supply this defect it has been the custom to dry the green food for the frosty season. Though the process of drying does not necessarily destroy or change the food elements of herbage, it has the effect of changing the action of the stomach upon them. Souring in the rumen does not go on as readily with dry food as with green. The same preparation for digestion is not made. The fiber in particular will hardly get soaked through before it is time for it to go out of the organ in which it was deposited. This impedes digestion and renders it imperfect. Aside from completeness of digestion, a cow can accomplish less on dry than on green food, because she can digest so much more of the latter in a given time. This fact is an argument in favor of ensilage, which, being green, digests so much more rapidly that more of it above the food for support can be utilized in the shape of milk. Ensilage, when skillfully preserved, varies less from the natural condition of food for the cow than when preserved by drying.

Green food in a tight silo and in the stomach of a cow is closely analogous in respect to condition and changes. The paunch of a ruminant is a silo in miniature, or, if you please, a well-built silo is a huge rumen for the reception and preparation of food for digestion. In each the food is partially comminuted, and in each exactly the same action is begun, namely, lactic fermentation. It may be carried a little further in the silo, if it remains long, but as far as they go the character of the changes in both is alike. The great disturbing element in ensilage is not the simple development of the lactic acid. It is the development of alcohol and vinegar, which only goes on when air is admitted to the silo. Their formation is accompanied with alteration and destruction. In some of the early earth pits more than half the original value of the food was lost by the penetration of air through walls of loose earth. So long as air is kept from the ensilage, alcohol and vinegar can no more form in it than in the stomach of a cow. The lactic fermentation will go on anyhow, closed or open, in the silo as in the stomach, but the change will be confined to the fermentation of lactic acid, the effect of which upon the food in which it occurs, though supposed to be unfavorable, has never been definitely determined. But, whatever that effect may be, the ensilage in a perfectly tight silo will scarcely be more altered from its normal condition than the cud of a cow from the grass it was made of. The point is to make the silo tight. Failing in this, changes detrimental to quality and waste have been the rule. But recently improvements in the construction have been very great, and loss and injury have correspondingly diminished. A perfect exclusion of air is the end to be aimed at.—*L. B. Arnold, in N. Y. Tribune.*

MULCHING FOR THE PEACH BORER.

A NEBRASKA farmer finds mulching the best remedy for the borer. He says: The borer is about as troublesome an enemy of the peach, especially in Nebraska, as any that I know of, and if not looked after in time will require labor and constant vigilance to get rid of. One or two are sufficient to destroy a young tree in a single season; four or five an old one. A little experience will soon enable any person to detect the borer in a peach tree. The most certain and obvious sign is the gum at the neck of the tree. Wherever this appears you may certainly conclude that the borer is at work. Several remedies have been prescribed for the borer. The one I make use of is mulching. I have two peach orchards. One I cultivated without mulching all the trees. The borers are at work in the trees not mulched. The other orchard I did not cultivate, but let the grass grow up and rot down. In it I find no borers at all.

PROGRESS IN AMERICAN SILK CULTURE.

THE ladies of the Silk Culture Association have lately reeled enough silk from cocoons raised in the vicinity of Philadelphia the past summer to make a dress pattern to be presented, it is said, to Mrs. Garfield. The quality of the silk is described as equal to that of the best Italian silk. The manufacture of the dress pattern has been undertaken by Messrs. Hamie & Booth, of Paterson, N. J. It is said, but incorrectly, that "when finished the garment will have the distinction of being the first entirely silk fabric made in America."

Garments were made of American grown silk fifty and even eighty years ago. This later achievement, however, gives promise, we trust, of a permanent and profitable revival of domestic silk culture.

FILTERING GELATINE EMULSIONS.

THE filtration of viscous solutions has always been a matter of some difficulty, and numerous appliances have been introduced for the purpose of hastening or simplifying the process, most of them depending upon the application of pressure to the surface of the liquid to be filtered, or the reverse—the exhaustion of the air from the vessel intended to receive the filtrate. In principle there is little difference between the two plans; but in practice it will, perhaps, be found that, according to circumstances, one or other way may prove the more convenient. In the case of the ordinary photographer the simplest and easiest to adopt will be the pressure plan, because it involves no expensive apparatus nor any departure from the ordinary circumstances of the dark room.

But on a large scale, as in the case of the manufacturer or even for the scientific amateur—if he possess a tolerably well-fitted chemical laboratory—the exhaust system will be as easy of application and perhaps more efficient in its action; indeed, where a large amount of work has to be done regularly, the exhaust system will be found by far the simpler both in application and use. The only difference between the two operations is that in one the emulsion to be filtered is inclosed in a vessel into which air is pumped, so as to force the fluid out through the filtering medium; in the other the emulsion is placed in a vessel, which may be of any form or character, provided it be capable of connection with a second and air-tight vessel. This is again capable of connection with an exhausting apparatus, which will draw the emulsion through the filtering medium into the air-tight receiver.

With regard to the exhausting apparatus: there need be no difficulty on the score of expense, as the onus of the labor may be cast upon the ordinary water supply cock. At almost any chemical dealer's may be obtained for a few shillings a simple form of "aspirator"—in other words, a modification of Sprengel's pump—which can be attached to the ordinary water tap if there be a sufficient fall of water. Of course, if the supply come direct from the main the pressure thus obtained answers every purpose admirably; but if the water be derived from a cistern it is necessary that the latter be placed as high as possible above the point at which the "aspirator" is used. Twenty or thirty feet is a desirable height, but we have found seven or eight to answer moderately well.

Where the pressure can be obtained from the main direct a very cheap and simple arrangement can be constructed for a few pence. Procure a short length of lead pipe about a quarter or three-eighths of an inch in diameter, and cut off (say) a foot; somewhere about the center of this perforate

the pipe and solder on a side joint, as in Fig. 1. The longer the portion from C to B the better it will work. If this be connected by means of an India-rubber tube with the water tap, the water from the latter in rushing down (under pressure) the tube, A B, will suck the air through the side tube, C, and so exhaust any vessel that may be connected with C.

Fig. 2 shows roughly an arrangement for filtering by exhaustion adaptable to any ordinary tap where the pressure comes direct from the main. If the tap be situated in a basement or lower story, and the immediate water supply be a cistern some feet above it, a similar though not so powerful exhausting action will be produced, provided the pipe running from the cistern to the tap be moderately straight and free from sharp turns. The jointed leaden "aspirator," A B C, may be left attached to the water tap as a fixture, and connected with the filter arrangement, D, by means of a stout rubber tube when the latter is required for use. Or the aspirator may remain fixed to the filter, and form part of it, to be attached to the water tap when required. It is desirable to have a moderate length of pipe between the points C and B; if it cannot be arranged to have a direct fall of two or three feet a length of India-rubber tubing may be attached to supply the deficiency.

FIG. 2.

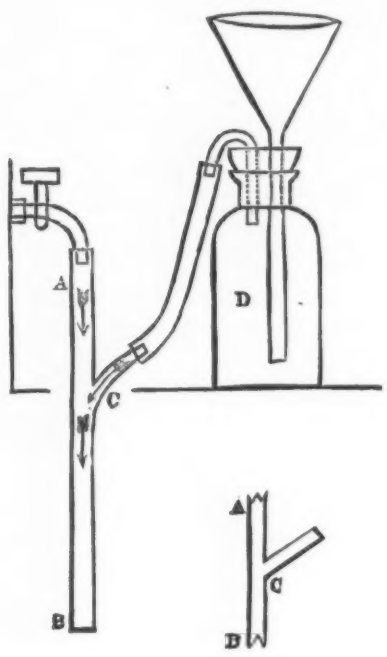


FIG. 1

As regards the filtering apparatus: the form shown appears to us to be as simple as can be devised, consisting merely of an ordinary bottle provided with a well-fitting cork, through which are passed a bent tube and a funnel. For a filtering medium, the latter may be lined with one or more thicknesses of wash leather, muslin, cambric, or anything of the sort. For very close filtration two thicknesses of wash leather with one of Swedish filter paper between will answer well. The wash leather will prevent the paper breaking under pressure.—*British Journal of Photography.*

MAGNETIC DISTURBANCES, AURORAS, AND EARTH CURRENTS.*

By PROF. W. GRYLLS ADAMS, F.R.S.

THE object of establishing a magnetic observatory is to determine at any instant the direction and magnitude of the earth's magnetic force. The direction of the magnetic force of the earth is the direction in which a small magnetic needle would point when it is freely suspended, so as to turn about an axis passing through its center of gravity. But it is not easy to suspend a magnetic needle so as to turn freely and yet to be sure that the axis about which it turns passes accurately through the center of gravity of the needle, and if it does not so pass, then on suspending the needle we have not only the magnetic force but also the gravitating force of the earth acting upon it to turn it about its axis, and the position which it takes up shows us the direction of these combined forces upon the magnetic needle.

This direction depends upon the mass of the needle, for to that its weight is due; it depends upon the form of the needle and the position of its center of gravity with regard to the axis on which it is hung; it depends also on the magnetic properties of the substance, so that it is not easy to determine even the direction of the magnetic force by a plan which theoretically is so very simple. Instead of attempting to make the required determinations by such a method it is necessary that a steadier mode of suspension should be adopted, and that may be done as soon as it is discovered in what vertical plan the force of gravity, combined with the earth's magnetic force, will cause such a needle to rest. This is usually done by loading a steel needle at one end and then magnetizing it with its poles so arranged that the extra weight of the heavier end shall balance the downward pull of the magnetic force on the other end. In this case the needle when magnetized will remain at rest in a horizontal direction, when suspended on a point on which it can turn freely in a horizontal plane.

A magnetic needle suspended in this way has been called a declination needle. Such a needle is employed in the mariner's compass, in our galvanometers for measuring currents of electricity, and in magnetic observatories for determining the declination, or what is sometimes called the variation of the magnetic needle. This needle determines the position of the vertical plane in which lies the direction of the earth's magnetic force; this is called the plane of the magnetic meridian. The plane of the *magnetic* meridian is usually different from the vertical plane through the north and south poles, which is called the geographical meridian, and the angle between these two planes is the declination or variation of the magnetic needle.

If such a magnetic needle as I have just described be supported on horizontal knife edges instead of being supported on a point, the needle when magnetized may remain at rest balanced in a horizontal direction, one end being pulled downward by the earth's vertical magnetic force, and the other by the force of gravity. Any change in the intensity of the vertical magnetic force of the earth will be shown by an up or down motion of the marked end of the needle. Such an instrument, called a balance magnetometer, is specially adapted for showing any changes in the vertical magnetic force of the earth, and the changes or disturbances of the earth's *vertical* magnetic force are determined by means of such a balance magnetometer. We have, then, our declination or variation needle to determine the vertical plane, called the magnetic meridian, and we have our balance magnetometer to determine any changes which may take place in the vertical magnetic force of the earth.

By the declination needle we can not only determine the plane of the magnetic needle, but by making the needle oscillate to and fro horizontally and counting the number of oscillations in a given time we can determine the horizontal pull upon the poles of the needle, *i. e.*, the intensity of the earth's horizontal magnetic force upon the needle, just as by the swing of a simple pendulum in a vertical plane under the action of the force of gravity we can determine the pull of the force of gravity upon the bob of the pendulum. By a similar method and by a properly suspended needle either the vertical force or the total magnetic force of the earth may be determined.

In order then to determine the direction of the earth's magnetic force we may make use of a declination needle to give us the vertical plane, and place the dipping needle in such a position that it will oscillate in that plane; when it comes to rest it will point in the direction of the total magnetic force, *i. e.*, in the direction through the room of Faraday's lines of magnetic force.

In order to determine the magnitude of that force the horizontal force may be found by finding the number of oscillations of the declination needle in the way that I have already explained, and these three determinations will give us the direction and magnitude of the earth's total magnetic force.

Another method of making the required determinations is to take a coil of copper wire, which is wound on a circular frame in such a way as to be capable of spinning on a diameter of the circular frame.

Faraday showed that on turning such a coil in a magnetic field a current of electricity is induced in the coil, and the strength of this current is proportional to the number of lines of force cut by the coil. We may describe such an arrangement as a magneto-electric machine, in which the magnet employed is the earth itself.

By means of this instrument we may determine either the horizontal or the vertical magnetic force of the earth. By placing the axis vertical and spinning the coil at a given rate we may determine the horizontal force, and by placing the axis horizontal in the magnetic meridian and spinning the coil at the same rate we may determine the vertical force, the currents produced in the two cases being in the same ratio as the numbers of the lines of force cut in the two positions.

The greater the angle at which the axis of rotation is inclined to the direction of the lines of force the greater will be the number of them included in the revolving circle, and the greater the induced current produced in the coil.

Thus placing the axis in different positions we get currents of different strengths, and may readily see that we get the greatest current when the axis is at right angles to the direction of the lines of force, *i. e.*, to the line of the dip.

We may further make use of such a coil to find the direction of the lines of force, for if we place the axis parallel to the lines of force, the currents in opposite halves of the coil will balance one another, because each line of force is cut twice by the coil, and so no current is produced in the external circuit through the galvanometer.

If then we place the coil so as to get no current when we rotate it, then the direction of the axis of the coil is the direction of the dipping needle, *i. e.*, of the magnetic lines of force.

We will suppose, now, that for some point of time, say June 1st at 12 o'clock midday, the three magnetic elements, *i. e.*, the declination, the horizontal force, and the vertical force, have been determined, we have now to consider the changes or disturbances produced in these magnetic elements, and the connection of these changes with other phenomena, and especially the connection between auroras, earth currents, and the larger and more irregular magnetic disturbances.

I have already drawn attention to the declination needle and the balance magnetometer for measuring the changes of declination and of the vertical force.

For measurement of the changes in the horizontal force a special instrument is employed, called a bifilar-magnetometer, in which a magnet is suspended by two threads, which are so placed that by their torsion acting against the magnetic force of the earth, the magnet is kept at rest in a horizontal position in a direction at right angles to the magnetic meridian.

This completes the list of instruments for our magnetic observatory.

Any change or disturbance of the horizontal force pulls this magnet round more or less in the horizontal plane, and its change of position is observed as in the other instruments. The results I have to bring before you this evening have been derived from the photographic registrations of similar instruments in different parts of the world, so that the motion of the needle has recorded its own tale on the prepared paper which is wrapped on a cylinder driven by clockwork, and so placed as to receive the spot of light reflected by the moving needle.

First, there are regular daily and yearly changes, showing that the sun produces regular changes in the three magnetic elements which depend on the time of the day and the season of the year, so that the change of position and apparent motion of the sun with respect to the place of observation produce regular magnetic changes. These regular daily changes are accompanied by and have very generally been supposed to be due to electric currents or electric waves traversing the earth's crust, and a discussion by Dr. Lloyd of the observations made by Mr. Barlow in 1817 of currents on telegraph wires showed a very close relationship between the two-hourly changes of the declination needle and the changes of intensity and direction of earth currents on telegraph lines.

Both Dr. Lamont and Dr. Lloyd conclude, from their comparisons of earth currents and magnetic changes, that the changes of the declination needle cannot be due to the direct action of the electric current traversing the earth's crust, but that these currents or waves, extending to a considerable depth, alter by induction the magnetism of the earth itself, and this change of magnetism causes the observed changes in the declination needle. Thus the magnetic changes are the indirect effects of (not the earth current in its immediate neighborhood, but of) a change in the magnetism of the earth itself, which may be due to an electric wave extending over a considerable area of the earth's surface

The point toward which the total earth current is directed follows the sun and seems to lag two or three hours behind, but not the same distance behind at different places.

These earth currents have been ascribed to different causes: thus Dr. Lamont regards them as the results of electric forces emanating from the sun; De Saussure regards them as developed by evaporation, the vapor being positively charged, and the water being negative; Dr. Lloyd regards them as effects of solar heat; while M. De la Rive ascribes them to chemical actions going on in the interior of the solid crust of the earth, the electricity being transported into the atmosphere by evaporation.

Mr. Ellis, of the Greenwich Observatory, has shown the intimate relation between solar action and the regular diurnal magnetic changes of declination and horizontal force at Greenwich Observatory during thirty-five years from 1841 to 1876, by a comparison of the observations of those elements. The results of his observations are shown on a large diagram which has been enlarged from his curves, and they show what a close relationship exists between solar storms and terrestrial magnetic changes. There are not only daily and yearly periods of the variations of the different magnetic elements, but there also seems to be in the horizontal intensity a period of twenty-five or twenty-six days, which is the time of rotation of the sun on his axis. Other recent investigations have shown that these regular magnetic changes depend not only on the sun, but that they are also in part due to the action of the moon, and these portions depend upon the length of the lunar day and on the position of the moon with regard to the earth. Just as there are regular earth currents whose direction depends upon the sun, which we may call the solar earth currents, so there are lunar earth currents which go through their changes under the action of the moon, and it has been shown that the effects are produced not immediately under the moon, but there is a lagging behind in the case of the lunar earth currents, just as in the case of the solar earth currents. In the case of the lunar earth currents we cannot attribute the production of the electricity either to heat or to thermo-electric currents from one part to another of the earth's crust, and we must, therefore, look for some other source. May we not find it in the fact that the moon causes tides in the solid crust of the earth, just as she causes tides in the oceans? The earth's crust is made up of elastic materials and materials capable of yielding and altering their form to a considerable amount with the change in the direction of the pull of the moon upon them. This crust also contains magnetic substances in abundance which alter their form under the moon's attraction, and so from the changes of position of masses of magnetic matter changes are produced in the magnetism of the earth which must give rise to induced currents of electricity or earth currents. Let us imagine a conductor of electricity outside the earth, stretching from the North Pole to the equator, and fixed in space, with the earth, a magnetic body, revolving beneath it from west to east; then it follows, from Faraday's laws of induced currents, that the revolution of the earth on its axis would cause a current in the fixed conductor in a direction from the pole to the equator.

If the conductor moved over the surface of the earth from west to east, and the earth did not revolve, or revolved at a slower rate, then the current in the conductor would be from the equator to the pole. The current depends upon the relative motion of the earth and the wire. If then we have an insulated wire running north and south, the tides in the earth's crust, of which I have spoken, will be equivalent to a lagging behind of magnetic matter, and so we may expect in that wire a current of electricity whose general direction would be from the equator to the pole. The position of the wire with reference to the magnetic pole of the earth would modify the direction of these earth currents, and it is quite conceivable that the position of England with regard to the magnetic pole might cause these regular earth currents to be greatest in the south-west and north-east direction. The lagging of the lunar earth currents behind the position of the moon would also be accounted for by the lagging of the tides behind the moon. If this is a true cause for some portion at least of the lunar earth currents, then the same reasoning applied to the sun may in a smaller degree apply to the case of the regular solar diurnal earth currents, and may help to account for the lagging behind of the effects due to the sun, so that the fact that the greatest solar effect happens about 2:30 P.M. may not be entirely due to the fact that that is the hottest part of the day, but may also in part depend upon the tides.

We have now to consider those more sudden changes of the suspended magnets, which are distinguished by the name, magnetic disturbances. In 1874 Dr. Lloyd said of them: "The duration and the magnitude of these oscillations are as yet outside the domain of law, and probably depend upon so many operating causes that, like the gusts and lulls of the wind in an atmospheric storm, they will long baffle all attempts to refer them to their actuating forces, or even to reduce them to order."

Certain facts relating to these disturbances have long been known. From the series of observations started by Gauss in 1834, and made every five minutes at the same time at a variety of places, at first in Europe and afterwards in various parts of the world, the disturbing power was found to increase in northern latitudes; also it was made out that the appearance of a disturbance in several places occurred at the same time, but there were great differences in the results at different places.

In Europe the agreement was very good, and also in America; but the agreement between Europe and America was not so satisfactory.

The force seemed to originate in a certain point in the interior of the earth, and the direction of the disturbing force seemed to be constant; yet sometimes there were great differences in the deviations at places not far apart, and from the result of his observations Weber was led to believe that there was a center of disturbances which was somewhere in the neighborhood of St. Petersburg.

However sudden and unconnected single disturbances may seem to be, they still follow certain laws in their occurrence; Sabine found that they had daily and yearly variations from their mean values, and that they have an eleven-year period, which agreed with the eleven-year period of the appearance of spots upon the sun.

Disturbances are more frequent in summer than in winter, and this applies to each hemisphere; and it has been confirmed by various observers that they are also subject to the influence of the moon. Lamont says of these disturbances:

* Lecture delivered at the Royal Institution, June 3, 1881.—*Nature.*

"Their cause is a force which is subject to certain laws, but which does not act constantly; the mean direction and frequency have yet to be discovered."

Observations have shown that the magnetic disturbances and electric currents on the earth are so nearly related to one another that people naturally look upon the electric currents, either in the crust of the earth or in the atmosphere outside it, as the cause of the magnetic disturbances. These currents in the earth have usually been attributed to changes of temperature, because they also are found to be in some way governed by the sun.

Now let us come to more recent observations of magnetic disturbances with the improved methods of recording observations by photography which are now available. For some years past photographic records have been taken of the magnetic elements, but the curves have been laid aside, and very little use has been made of them; so much so that some three or four years ago a circular letter from Mr. Ellery, Director of the Melbourne Observatory, was sent round to those scientific men who were supposed to be interested in the matter to know whether it was advisable to continue the photographic records of magnetic changes at Melbourne, which is the most southern station, and the only station in the southern hemisphere except Mauritius, where such observations are taken. Mr. Ellery did not for one moment suppose that they were of no value, but as no use was made of them he wished to know whether the money expended might not be better applied to another purpose. This matter has been taken up by Kew Committee, of which Dr. De la Rue is the chairman, and a recommendation was made that the directors of all observatories which possess instruments of the Kew pattern should be invited to send to Kew their photographic records, or careful tracings of them, for a given period, so that a comparison might be made of the results.

The period chosen was the month of March, 1879, and records for the whole month have been sent from Lisbon, Coimbra, Stonyhurst, Vienna, St. Petersburg, and Bombay, in the northern hemisphere, and from Melbourne and the Mauritius in the southern hemisphere.

A preliminary account of a comparison of the declination curves from the European stations was brought before the British Association last year at Swansea, and this evening I have to bring before you some further points which come out of these comparisons. Let us take the disturbances on March 15–16, 1879, which will illustrate some of the points which I wish to bring out prominently.

Not only do magnetic changes occur at the same time at different stations, but there is a great similarity between them.

It must be remembered that at the northern stations the horizontal force is smaller in proportion to the whole force than it is at stations nearer to the equator, so that the same disturbance will produce less effect on the horizontal force or on the declination needle in latitudes near the equator.

Also the needles at different stations are by no means in the same state of sensibility, and even at the same station they change with time, so that they are not always equally sensitive, and when they lose their magnetism they have to be remagnetized.

We see that soon after 10 A. M., G. T., on March 15, 1879, there is a disturbance wave showing first a diminution and then an increase in the horizontal force at St. Petersburg, Vienna, Kew, and Lisbon. At Melbourne, in Australia, there is a similar disturbance at the same time both in the declination and in the horizontal force.

Again, between 2 and 3 and between 4 and 5 P.M. there are very small disturbances showing themselves at the same absolute time in the horizontal force and declination curves. About 5.20 P.M. there is a well-marked increase in the horizontal force and eastward deflection of the declination needles. About 9.30 P.M., G. T., a storm begins which lasts for about an hour. It is felt in the northern and in the southern hemispheres, near to and on both sides of the equator. At all European stations the horizontal force is increased during the first part of the storm, and then diminished.

At Lisbon the vertical force is first increased and then diminished, and at St. Petersburg and Stonyhurst there is a diminution in the vertical force at the same time as at Lisbon. If we regard the declination needles, we find that at St. Petersburg, Zi-ka-wei, and Melbourne, and at Bombay, the declination westward is first increased and then diminished, whereas at Kew and Lisbon the motions are in the opposite direction.

The declination at Vienna seems to be intermediate between Kew and St. Petersburg, but the curve is incomplete.

At Bombay and the Mauritius, near to but on opposite sides of the equator, the declination needles are deflected opposite ways. The local time at these places was from 1 to 2 o'clock at night.

Now in what way can we account for such magnetic disturbances as this? If we assume that by magnetic induction from some cause or other the earth's magnetism is altered, then the position of the magnet which would produce the disturbance must be such that its pole which attracts the marked end of our needle must lie at the beginning of the disturbance to the east of Kew and Lisbon, to the north of Vienna, and to the north-west of St. Petersburg; the Lisbon vertical force curve also shows it to be below the surface of the earth. Hence an inductive action equivalent to a change of position of the north magnetic pole toward the geographical pole would account for these changes. The strengthening and weakening of a magnet with its north pole to the north on the meridian of Vienna might possibly account for the magnetic changes observed between 9.30 and 10.30 at night, Greenwich time, on March 15, 1879.

If we attempt to explain this disturbance by currents of electricity or discharges of statical electricity in the air above the needles, then we must imagine that at first there is a strong current from the south-west over St Petersburg, from the west over Vienna, and from the north-west over Kew and Lisbon, the vertical force needle at Lisbon showing that the current from the north-west lies somewhat to the east of Lisbon, that at the Mauritius this current is from the north, and at Bombay from the south.

Hence we must imagine that a current of electricity passes down from north west to the south-east, going on toward the east over Vienna, and towards the north-east over St. Petersburg. This must be kept up very much along the same line throughout the first part of the disturbance, and then the current or currents must be altered in strength in the same manner at all stations.

We will next consider what would hardly be called a magnetic storm, but a few very small deviations of the magnetic needle, lasting from about 5.30 to 7.30 P.M. on March 26, 1879. Only the comparison of the originals will give the closeness of the similarity of the curves, and the curves for Vienna and Kew are absolutely coincident.

When the declination needle is deflected to the west, the horizontal force needle is deflected with its marked end toward the south, so that in this disturbance the two needles are drawn toward the south-west at the same time with greater or less power, and twelve similar bends are clearly traced out in the Vienna and Kew curves during the two hours. These disturbances are all so very small, that but for the comparison of photographs they would probably be lost sight of; yet we see that the same deflections occur at the same instant at Kew and at Vienna, at St. Petersburg and at Melbourne. From the remarkable similarity in these disturbances and their occurrence at the same time, we should expect that the cause of disturbance is so far removed from the places of observation that the difference of their distances from it need not be considered. This might not unreasonably be urged as an argument in support of a theory that such disturbances are due directly to the action of the sun regarded as a magnetic body. The numerical comparisons of observations made every five minutes on certain days previously fixed upon would probably never have shown the way in which these minute changes of magnetic power of the earth at widely distant places are related to one another.

In one or two cases Senor Capello and Prof. Balfour Stewart had compared the Lisbon and Kew curves for a particular disturbance, but the photographic magnetic records have never before been collected from other stations, and there has been no opportunity of comparing them. From the precise similarity of the forms of the curves in many cases we may say that the *rate of change* of magnetic disturbances at widely distant stations is the same. There is nothing fitful or flashing in such disturbances as these of March 26. We might imagine a current in the crust of the earth or a current or transfer of electricity in the air near to, *i. e.*, within twenty or thirty miles of each of these observatories, but to imagine the same current and the same variations of the current at so many different stations, all changing in the same way at the same instant, is difficult, unless it can be shown in what way all these changes are connected with the cause of such a regular electric discharge. It seems easier to imagine that such changes as these are due to a change produced by induction in the magnetism of the earth itself by some distant body. It is easy to show that the magnetism produced by a current in a magnetic substance round which it flows is greater in its action on a small magnetic needle than the direct action of the current itself. Hence a current flowing in the crust of the earth should produce its principal effect on a magnetic needle by the magnetic induction which the current induces in the earth itself.

Sometimes disturbances occur where at the same instant there are similar deflections of the declination needles at stations wide apart, and suddenly at one of the stations the needle no longer goes with the others, but begins to go, and continues for a considerable period to go, in the opposite direction to the others, turning when they turn, and tracing out a similar curve, but turned always in the opposite direction. Such cases occurred frequently during March, 1879, and especially on March 23, about 1.30 and about 7 P.M., Kew time, and on March 29, about 9 P.M. An examination of the principal disturbances seems to show that:

(1) A diminution in the horizontal force is accompanied by greater easterly deflections of the declination needle at St. Petersburg than at Kew.

(2) Increase of the horizontal force is accompanied by greater westerly deflections at St. Petersburg than at Kew, or is sometimes accompanied by a westerly deflection at St. Petersburg and an easterly deflection at Kew.

These cases which I have taken will be sufficient to show how important it is that there should be additional magnetic observatories, especially in the southern hemisphere, where photographic records should be taken, so that we may learn something about the magnetism of the earth. Practically we have to rely on one excellent observatory (Melbourne) for the whole of the southern hemisphere. Surely the time has arrived when there should be photographic registration of the magnetic elements at such an important observatory as the Cape of Good Hope, especially when the French Government has decided within the last few weeks to establish a magnetic observatory at Cape Horn. With observatories at Melbourne, at Cape Horn, and at the Cape of Good Hope, the southern hemisphere would be well supplied, and probably the Russian Government would then soon establish an observatory in the east of Siberia.

Now we can readily show the way in which the magnetic instruments are disturbed in a magnetic observatory by the alteration of the strength of a magnet. Taking magnetic needles to represent the declination needle, the inclination needle, and the bifilar or horizontal force needle, we may place an electro-magnet in a given position with regard to them, and by altering the strength of that electro-magnet may cause these needles to trace out disturbances of a very decided character. In the disturbance of March 26 the greatest motion of the needle was not more than about 2′ of angle at Kew or at Vienna. It would not be possible for me to show you the action on so small a scale.

I have as yet been speaking of only moderate disturbances, but now let us come to some of the larger ones, and I have had the opportunity, through the kindness of the Kew Committee, and the observers at the various observatories mentioned, of studying the curves for the August magnetic storm which began at 10.20 A.M., Greenwich time, on August 11, and for convenience may be divided into three storms, one lasting from 10.20 on the 11th, to 1 A.M. on the 12th; a second from 11.30 A.M. on the 12th to 7.20 on the 13th; and the third from 11.50 A.M. on the 13th to 7 to 8 A.M. on the 14th of August,

I have prepared a large sheet, on which these curves have been copied as accurately as possible for the first of these storms on the 11th. For this storm I have also the curves from Toronto and from Zi-ka-wei. The first storm began on August 11 at the same instant at all the stations. There is a decided similarity, especially in the horizontal force curves, throughout the first part of this storm, and certain points in it stand out prominently. At Kew, the beginning of the storm is not actually recorded, because the sheets of prepared paper on the time cylinders were changed precisely at 10.20 A.M., when the storm was beginning. The deflections are alike at Lisbon, Kew, Vienna, St. Petersburg, and after the very first sudden deflection, at Toronto also. The greatest effect is produced at St. Petersburg; the similarity between the large disturbances at Vienna and at Toronto in Canada, places differing about 6½ hours in time, is remarkable. About 11.45, 1 P.M., and 2.40 P.M., there are very remarkable points of agreement.

From about 4.30 P.M. to 8 P.M. Greenwich time, *i. e.*, from about 11 A.M. to 2.30 P.M., Toronto time, the deflections are opposed at Toronto, and at Vienna or Kew.

This would rather point to solar action as the cause of disturbance. In this case the Kew curve is not so much deflected as the Vienna curve, because the horizontal needle at Kew is not nearly so sensitive as at Vienna, and the relative strengths of the actual disturbing forces at the two places can only be obtained by comparison of the scale-values at the two places.

I will draw your attention to one other point on this day. At 9 P.M. the disturbances are all in the same direction, but about 11 P.M., while St. Petersburg agrees in direction with the others in a very violent phase of the storm, at Toronto the direction of the deflections is reversed, and this reversal of curves continues until about the end of the first of the three storms.

The second storm, beginning about 11.20 A.M. on the 12th, and lasting until the next morning, was the most remarkable of the three. It not only baffles the telegraph clerks, who wish to keep out earth currents from their lines, but it even goes beyond the powers of the magnetic observatories which are specially designed to watch over them. Thus, at Toronto, the line goes off the edge of the paper on which the photographic record is taken. At Melbourne the motion is so rapid, and also at Vienna, that the plate is not sensitive enough to receive the impressions; the motion is too quick even for photography. At the time of greatest disturbance, about 12 20 midday, it is very remarkable that at Lisbon, and at Zi-ka-wei, near Shanghai, in China, two places nearly in the same latitude, but nearly nine hours apart in time, the vertical force is increased in precisely the same way and to the same amount at the same instant.

At Zi ka wei in China, the sudden change in the horizontal force on the needle amounted to about one one-hundredth part of the total horizontal force, and at St. Petersburg the change in the horizontal force amounted to one-thirty-fifth part of the horizontal force, and the total force was changed by about the one-eightieth part of its full value.

Hence, any cause for these magnetic changes, in order to be a true and sufficient one, must be capable of producing such intense magnetic changes as these all over the surface of the earth. These magnetic changes are so large as to be quite comparable, as we see, with the earth's total force, so that any cause which is shown to be incompetent from the nature of things to produce the one can hardly be held to account for the other.

Since, as I have shown, the large disturbances and the small disturbances do not follow totally different laws, but agree equally well all over the earth, in so far as they agree we must attribute them to the same cause.

During this August storm, as also during the remarkable storm of January 31 last, great difficulties were experienced in working the telegraph lines, and Mr. Preece has been kind enough to send me particulars of these storms.

I am also greatly indebted to the Astronomer Royal for sending me traces of the earth-current photographic records taken at Greenwich Observatory during the August storm on two separate wires, one running from the north-east, and the other from the south-east, to Greenwich. The two tracings are bent opposite ways at the same time, so that when a current was running on one line toward Greenwich, on the other it was running away from it; and comparing these curves with the earth current records from Derby and Haverfordwest and other places, it appears that the general direction of currents during this storm was from south-west to north east, or from south south west to north-north-east, with varying intensity, the agreement being very close between the disturbances of the declination needle and the Blackheath and Greenwich photographic record. From Mr Preece's record also earth-currents were violent from 10.30 A.M. on the 11th (*i. e.*, they were noted within ten minutes of the beginning of the magnetic storm) to about 2.30 P.M., and again from 9 to midnight.

They were very violent on August 12, beginning at 11.30 A.M., the beginning of the second storm, and quieting down about 4.30 P.M., then beginning again at 7.30 and lasting until 9.30 P.M.

Again on the 13th they are strong for 1½ hours, from about 5 in the morning, *i. e.*, just about the end of the second magnetic storm.

The general direction of the earth-currents as observed at Derby or Haverfordwest, as well as at Greenwich, was from north east to south-west.

Again on January 31 last, another violent magnetic storm occurred, in which the currents were even more violent than in the August storm.

Intimately connected with magnetic disturbances and earth currents is the phenomenon of the aurora or polar light, which is an electric discharge in the upper regions of the atmosphere. During the August and January storms the aurora was well seen in England; it was also seen at St. Petersburg, and as far east as Siberia. It does not appear to have been seen, although it was looked for, at Zi-ka-wei in China by M Dechevrens, the director of the observatory, although the magnetic storm was so violent there that the horizontal force was suddenly changed by one one hundredth part of its total amount.

We may arrive at some idea of the character of the aurora by studying electric discharges in vacuum tubes, and Dr. De la Rue has already brought this subject before you in his Friday evening lecture.

We may gradually pass from electric discharges in air of ordinary density, in which we get the well-known electric spark between two surfaces, to air of less density but better conducting power, and then to air of less density still, but of such high resistance that no electricity will pass. Dr. De la Rue has shown that with 11,000 cells of his battery the striking distance between two points is about six-tenths of an inch in air of ordinary density of about 760 mm. pressure.

When the pressure in a hydrogen tube is reduced to 21·7 mm., 8,937 cells will cause a discharge to take place through thirty inches.

When the pressure is reduced to 0·642 (about six-tenths of a mm.), 430 cells will cause a discharge through the tube.

When the pressure is still further reduced to 0·0065, it requires 8,937 cells to cause a discharge, so that the spark passes more readily at a pressure of 0·642 mm than it does at a higher or a lower pressure. This is also the case with air.

The lower regions of the earth's atmosphere offer great resistance to the passage of electricity, but as we ascend the pressure diminishes and the electric resistance diminishes, until at last, at a height of between thirty and forty miles, a level is reached where the air offers least resistance to the passage of electricity, where the pressure is about 0·397 of a mm., and above that level the electrical resistance again increases, so that at a height of about eighty miles the battery of 11,000 cells would not cause a spark to pass.

If we take a tube which has not been very highly exhausted we see that the light from the positive pole extends nearly through the tube, and the dark space around the negative pole is small. As the exhaustion proceeds and the pressure of the air is diminished, the electric spark passes through

greater and greater lengths and changes its character, until we get to the pressure corresponding to the least resistance. Beyond that the resistance increases, the dark spaces around the negative pole expands, and the molecules fly about more freely; those on the negative plate being charged with electricity, and being repelled from it proceed for a long distance in straight lines, and possess the power of causing bodies on which they strike to glow. In Mr. Crookes's tubes we get very beautiful effects from this glowing of the glass tube itself, or from the glowing of substances in the path of the stream. We may regard this as a stream of molecules of gas charged with electricity, and we see the difference between this stream and the electric current in a vacuum tube at lower exhaustion by the action of the magnet upon it. In one case the current going through the molecules from pole to pole in the tube is bent out of its course by the magnet, and symmetrically by the two poles, and returns to its path, the line of least resistance, through the molecules, whereas the stream of molecules at the higher exhaustion, carrying their electricity with them, are carried away by the electric charge upon them, and get utterly lost and scattered on striking the side of the tube, yielding up a great deal of energy in the form of heat to the tube or to the glowing platinum or other substance in the tube.

I must now show you the beautiful aurora tube which has been seen once in this theater, and for which I am indebted to the kindness of Dr. De la Rue. It has been brought to the right state of exhaustion to show just those effects which will help better than any description of mine to give you an idea of the character of the aurora discharge in the middle regions of the atmosphere.

By bringing a magnet to bear upon this discharge we may see the effect of terrestrial magnetism on the aurora discharges in the atmosphere.

Aurora Borealis.—The aurora as seen in the north-eastern parts of Siberia, where it is often very brilliant, is described as consisting of single bright pillars rising in the north and in the north-east, gradually covering a large space of the heavens; these rush about from place to place, and reaching up to the zenith, produce an appearance as if a vast tent was spread in the heavens, glittering with gold, rubies, and sapphires.

More exact attempts have been made to describe the aurora, and perhaps I may be allowed to quote Dalton's description of an aurora as seen by him.

A remarkable red appearance of clouds was noticed in the southern horizon, which afforded light enough to read by, and a remarkable effect was expected. He says: "There was a large luminous horizontal arch to the southward, and one or more concentric arches northward. All the arches seemed exactly bisected by the plane of the magnetic meridian. At 10·30 streamers appeared in the S. E. running to and fro from W. to E.; they increased in number, and approached the zenith, when all of a sudden the whole hemisphere was covered with them, and exhibited such an appearance as baffles all description. The intensity of the light, the prodigious number and volatility of the beams, the grand intermixture of all the primitive colors in their utmost splendor, variegating the glowing canopy with the most luxuriant and enchanting scenery, afforded an awful, but at the same time a most pleasing and sublime spectacle. But," he adds, "the uncommon grandeur of the scene only lasted one minute. The variety of colors disappeared, and the beams lost their lateral motion, and were converted, as usual, into the flashing radiations; but even then it surpassed all other appearances of the aurora, in that the whole hemisphere was covered with it."

In his address before the British Association in 1863, Sir William Armstrong speaks of the sympathy between forces operating in the sun and magnetic forces on the earth, and notices a remarkable phenomenon seen by independent observers on September 1, 1859.

"A sudden outburst of light, far exceeding the brightness of the sun's surface, was seen to take place, and sweep like a drifting cloud over a portion of the solar surface. This was attended with magnetic disturbances of unusual intensity, and with exhibitions of aurora of extraordinary brilliancy. The identical instant at which the effusion of light was observed was recorded by an abrupt and strongly-marked deflection in the self-registering instruments at Kew. The magnetic storm commenced before and continued after the event."

The daily and yearly periods of the magnetic changes, the change in the horizontal force depending on the sun's rotation on his axis, the agreement of the eleven-year period of magnetic disturbances, sun-spots, and auroras, show that the sun plays a very important part in causing or governing both the regular and irregular magnetic changes.

If the sun be assumed to be a very powerful magnet, then changes in his magnetism might be expected to affect the magnetism of the earth, although the effect could not be very large, unless the sun is magnetized to an intensity much greater even, compared to his mass, than the earth is magnetized. Then as there are tides in the sea around us and probably in the earth's crust, so there are certainly very large tides in the ocean of air above us; and may not the sun and moon, by dragging this air toward them as the earth revolves, cause that friction between air and earth, and also that evaporation, which together may account for the presence of, and keep up the supply of, positive electricity in the air and negative electricity in the earth? Again, these tides in the atmosphere will cause the mass of it to lag behind the revolving solid earth, and at a height of thirty or forty miles we have a layer of air which, for air, is a comparatively good conductor of electricity. Here then we have not a lagging of the magnet behind the conductor, but a lagging of the conductor behind the magnet, and hence, according to the laws of Faraday, we may expect a current or a gradual heaping up of electricity in the air in the opposite direction to the current in the earth's crust. Thus the regular tidal waves in the atmosphere would cause the gradual transfer of positive electricity from the poles toward the equator. This transfer may be of the nature of a current of electricity or of a mass of air carrying a static charge of electricity with it, for, as Prof. Rowland has shown that the motion of a static charge will produce magnetism, so we may expect from the principles of conservation of electricity that a change in the position of a magnet will under such circumstances produce motion of the static charge of electricity. When the air becomes charged up to discharging point, then we may get the sudden discharges such as the aurora in the air and the earth current in the earth; and since the conducting layer of air approaches nearer to the earth in the colder polar regions, possibly within less than twenty miles of the earth's surface, it may be found that the discharge of the aurora may even take place from earth to air by gradual slow discharge, aided as it may be by the state of moisture of the air and by change of temperature and other causes.

THE SUN'S COLOR.

IN his new publication, *Knowledge*, Mr. R. A. Proctor has been commenting upon Professor Langley's theory that the sun is in reality not a white sun, but a blue one, the apparent whiteness being due chiefly to the absorptive action of his own atmosphere, and partly to that of our own air. Mr. Proctor's observations are suggestive, because they point out the value which photographs of the sun have in relation to this interesting question. The sun, as seen by the naked eye, appears more luminous in the center of his disk than at the edge, and the difference can only be due to the effect of absorption exerted by the solar atmosphere Mr. Proctor thereupon remarks that any one who studies a photograph of the solar disk will notice that the darkening toward the edge is much more marked there than it is in the ordinary photographic disk of the sun, and says: "It follows that those rays which produce the photographic image of the sun (chiefly the blue, indigo, and violet rays) are more affected by the absorption of the solar atmosphere than those which form the ordinary visual image of the sun. His atmosphere then acts more strongly to absorb the rays belonging to the blue end of the spectrum than the rays belonging to the red end. The sun's apparent color, therefore, is less blue than his real color. If his atmosphere were suddenly removed, he would change from his present white or whitish-yellow color to bluish, or, perhaps, greenish, precisely as the setting sun, if the air between the eye and him were suddenly removed, would change from his apparently ruddy hue to the white color of the overhead sun." As the sun constantly varies in color according to the state of the atmosphere, a difference between his real and apparent color might have been presupposed. It is, however, gratifying to find that photography has played a useful part in determining this point, as it has done in reference to so many other departments of science.

THE SKY AS A CEMETERY.

"I HAVE been watching the star called the Winking Demon," said the astronomer, as he extended his hand to pull a *Sun* reporter up on the roof. "These autumn mornings are a little chilly, but the air is so deliciously pure and clear that one doesn't mind if it bites a little. Besides, it is worth the risk of catching cold to see the Demon wink. You are just in time to watch him as he gradually reopens his eye. If you had come a few minutes earlier you might have seen him shut it."

"Where is this remarkable demon star?"

"There, almost overhead at this hour. If you want to point him out to your friends you have only to observe that he is a little south of that bending row of stars that marks the constellation Perseus, and that there is a little group of smaller stars near him. Now, you see, his light is pretty faint, but not so faint as it was a few minutes ago. In three or four hours his eye will be wide open again, and he will shine as a star of the second magnitude. These winkings of Algol, or the Demon, occur a little oftener than once in three days."

"What causes them?"

"Ah, now you come to the strangest thing of all. Is there anything in the appearance of the sky, all glittering with stars, that suggests to your mind that it may be a vast cemetery? No, ridiculous! you say. Very well. You will not dispute that the earth we tread is, from one point of view, only a great burying ground, which contains the remains not only of countless generations of men, but of whole races and tribes of various animals and plants. Just so in the heavens about us the dead are mingled with the living. It is to my mind the most suggestive discovery of modern astronomy that the universe is full of dead suns—suns whose light has gone out, whose fires have been extinguished, and which no longer shed life-giving and life-preserving rays upon the worlds that may be imagined yet circling in coldness and gloom about them. What has this to do with the Winking Demon? Why, everything. I believe it is generally conceded, though Prof. Newcomb seems to dissent, that the variations in the light of Algol are caused by some huge dark body revolving around it at a frightful rate of speed. There are other variable stars whose phenomena can be accounted for in the same way. In the case of Algol there is evidence that the dark body is rapidly approaching the star, drawing nearer with every circle. When it strikes, if it is to strike, who can picture the extent of that catastrophe? Then, indeed, that mysterious dark body will become visible, blazing with the light of a hundred suns, and unable to escape from the fiery destruction that it has brought upon the star."

"Are there any other dark bodies like this known to astronomers?"

"Oh, yes; the great star Sirius is accompanied by a huge body of the kind. It is not altogether dark, for with large telescopes it can occasionally be seen glimmering faintly close to the star. Astronomers knew it was there before they got a glimpse of it, for it caused disturbances in the proper motion of the star. Another of these dark bodies which astronomers are sure exists, although no human eye ever saw it, is dogging the star Procyon, one of the brightest in the sky. You may see the star now low down in the east, north of Sirius and below the Twins. The invisible body that hovers about it is evidently of large size, for it causes considerable perturbations in the star's motion. It may once have been a sun as brilliant as Procyon itself, but now not a ray comes from it. Still, astronomers can point out the changes in its position, as its attraction pulls the star now this way and now that.

"If space is filled with these mysterious dark bodies, collisions between them and living, or light-giving, suns are not impossible. You know that our sun is in rapid motion, carrying his family of worlds along with him in his flight. So all the stars are instinct with motion. Our lives are so short and their distances are so great that we can hardly appreciate these motions, yet they are swift beyond comprehension. Some of the stars are approaching, others receding, all moving in some direction. The constellations whose forms are so familiar to us are falling to pieces like card houses. In a few thousand years there will be no Great Dipper, no Orion with its club, no Southern Cross. The heavens would look like a new universe to one of us who revisited the earth in the ten thousandth century. Now, if we suppose that there are as many dark or dead suns as there are living ones, it is not difficult to believe that occasionally there might be collisions between them. Of course the chances against any such collision would be very, very great, and yet some of the cases of stars that have suddenly blazed out with astonishing brilliancy and then disappeared may be accounted for in this way. To show you that there is no exaggeration in what I am saying about the multitude of dead suns in the universe, see what Sir John Lubbock said in his inaugural address at the meeting of the British Association in August last:

"'The floor of heaven is not only 'thick inlaid with patines of bright gold,' but studded also with extinct stars, once probably as brilliant as our own sun, but now dead and cold, as Helmholtz tells us that our sun itself will be some seventeen million years hence.'

"But we need not wander off in space in search of the sky's untombed dead. We have right at hand, circling about our own earth, not an extinct sun, but a dead world. The moon is dead, and has been dead these million years. There the astronomer, if he fancies himself the world's surgeon, may study the effects of a malady that no surgery could cure. Even worlds and suns, like men and women, grow old and die; but unlike men and women, they have no grave but the open and boundless heavens."

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